REPORT

ON THE

MEDICO-MILITARY ASPECTS

OF THE

EUROPEAN WAR

By SURGEON A. M. FAUNTLEROY, U. S. N.

1915

Robert I. Rhodes.

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MEDICO-MILITARY ASPECTS
OF THE
EUROPEAN WAR

FROM OBSERVATIONS TAKEN BEHIND THE
ALLIED ARMIES IN FRANCE

By

SURGEON A. M. FAUNTLEROY, U. S. NAVY

INSTRUCTOR IN SURGERY, UNITED STATES
NAVAL MEDICAL SCHOOL

UNDER THE DIRECTION OF THE
BUREAU OF MEDICINE AND SURGERY
NAVY DEPARTMENT
WASHINGTON, D. C.

WASHINGTON
GOVERNMENT PRINTING OFFICE
1915

FOREWORD.

In gathering the data for this report my one effort has been to present only facts from which a lesson could be learned. The sources of information have been numerous, and while the names of various individuals appear throughout the text as being responsible for certain statements, I wish to acknowledge the kindly assistance of many who made it possible for me to acquire, through personal observation, the necessary details which form the basis of this report.

His Excellency M. Jusserand, the French ambassador at Washington, gave me letters of introduction which were of great value in carrying on my work in France. I am particularly indebted to Dr. Joseph Blake, who appointed me a member of his operating staff at the American ambulance in Paris, where I served on his surgical service for two months. To Lieut. Commander W. R. Sayles, United States Navy, the naval attaché at the American Embassy in Paris, I am also grateful for his many acts of kindness and consideration. Mr. Lawrence V. Bennet, an American engineer resident in Paris, gave me the facts in connection with ballistics. Maj. James A. Logan, jr., Subsistence Department, United States Army, who was one of the military observers attached to the American Embassy in Paris, is responsible for the information in regard to the French Army ration and many helpful hints on a variety of subjects.

M. Bijot, of the French War Office, was most cordial in his successful efforts to obtain permission for me to visit the front on a number of occasions. Gen. Sorin, commanding the military district of Arras-Bethune, was particularly kind in furnishing me with every facility for conducting my observations along that part of the front. M. Robin and M. Margoles, French engineers in charge of military roads, not only greatly aided me in every way during my stay in the neighborhood of the Labyrinth, Notre Dame de Lorrette, Vermelles, and La Basse, but took me into their mess and quarters for 12 days. Dr. Alexis Carrel gave me every opportunity

to visit all the field hospitals in the region between Compiègne and Soissons.

One of the hardest features in connection with making this report was the effort to sift the wheat from the chaff in order to arrive at the real truths and lessons to be gleaned from contact and conversation with a large number of surgeons of many nationalities, whose observations and ideas were ofttimes at variance; and it was therefore necessary to correlate the experiences of these many different observers before an estimation could be made as to the real facts. Particularly was caution exercised in recording the views of enthusiasts, or those who had many and obvious reasons for wanting to exploit their own pet ideas.

I wish to extend my grateful appreciation to Passed Asst. Surg. E. H. H. Old, United States Navy, and to Passed Asst. Surg. R. C. Ransdell, United States Navy, for correcting the proof and indexing the contents of the text.

A. M. F.

Washington, D. C., *November 15, 1915.*

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NAVY DEPARTMENT,
Washington, March 27, 1915.

To: Surg. Archibald M. Fauntleroy, U. S. N., Naval Hospital, Washington, D. C. (commandant, navy yard).

Subject: Detached, Naval Hospital, Washington, D. C., to assistant to naval attaché, Paris, France.

1. On April 20, 1915, you will regard yourself detached from duty at the Naval Hospital, Washington, D. C., and from such other duty as may have been assigned you; will proceed to New York, N. Y.; thence to Paris, France, via the French Line steamer *La Touraine*, sailing on or about April 24, 1915.

2. Upon arrival at Paris you will report for duty as assistant to the naval attaché.

3. This employment on shore duty beyond the seas is required by the public interests.

4. The State Department has been requested to designate you as assistant to the naval attaché, Paris, France.

5. The Navy pay office, New York, N. Y., has been requested to furnish you transportation from New York to Paris via above-mentioned steamer to Bordeaux.

JOSEPHUS DANIELS.

THE MEDICO-MILITARY ASPECTS OF THE EUROPEAN WAR FROM OBSERVATIONS TAKEN BEHIND THE LINES OF THE ALLIED ARMIES IN FRANCE.

PART I.

MILITARY ORGANIZATION AND EQUIPMENT.

When the medico-surgical history of the military operations of the Allies in France is written it will contain large reference to the different phases of the war as exemplified in the German advance, retreat, and entrenchment as having a direct bearing on the problems that had to be solved as they arose by the medical officers of the allied armies.

Germany's declaration of war on Belgium, France, and England in August, 1914, was followed by the swift and sure movements of her well-oiled and constantly cared for fighting machine, a machine which had been perfecting itself for over 40 years to meet just the conditions confronting it at the outbreak of hostilities. Before France and England realized that war was inevitable Germany had made certain overtures to Belgium and Luxemburg with reference to the passage of her troops over their neutral territory, as being apparently a part of a long-standing and well-matured plan of attack. Luxemburg being a negligible quantity, how far Germany realized or cared for the resistance that Belgium might offer only the archives of Wilhelmstrasse can answer. As to the political aspect of such a situation, involving the rights of neutrals, it is not within the province of the military surgeon to comment upon, beyond recording the devastation and almost total destruction of the country following Belgium's refusal to sanction any idea of a violation of her neutral rights by a belligerent. This condition of affairs at the very outset of the war taxed the available civil and military medical men far beyond their capacity to meet. The many thousands of refugees, numbers of whom ultimately succumbed to starvation and exposure, together with the rapidly increasing number of daily wounded, completely overpowered the relatively few medical men and nurses.

That Belgium's sturdy defense and stubborn resistance upset a number of Germany's calculations is now well understood. It is practically conceded by many military men that Belgium's stand at least saved France and had further far-reaching effects on Germany's future campaign. It is a matter of record that it was something over three days before France could mobilize a small army on the Franco-Belgian frontier, a fact that carries its own significance as regards any idea of French invasion of Germany through that quarter. When one realizes that, despite Belgian resistance, it took Germany only 29 days to get within big-gun distance of Paris, it is a matter of fairly easy speculation as to the outcome of their plans had they not been delayed in passing through Belgium. Long before the final fall of Liege, Louvain, Brussels, Namur, and Mons five well-equipped German armies were straining at the leash, but could not afford to make the dash on Paris with an unconquered Belgium on their flank, which in a short time would also invite a serious menace to their lines of communication by allowing England the opportunity for an unobstructed landing in Belgium.

Having once adopted this method of invading France, instead of by way of the Franco-German frontier, the German forces vigorously engaged the French frontier garrisons, and the defense all along the line, in order to prevent reinforcements being sent to the practically undefended Franco-Belgian frontier and also to feel out the strength of the French resistance. How well this plan succeeded and prevented French concentration on the scarcely defended western end of the frontier, is now a matter of history. Although French military preparation is organized along the lines of national service and enforced military training of three years with the colors, it is a much slower moving and less automatic machine than the German organization, besides being greatly outnumbered by the latter both on a peace or war footing. The economic conditions in the French Republic have always tenaciously pulled away from an energetic military policy in contrast to the Prussian military spirit which has dominated Germany for over 40 years, and upon which the entire economic structure of the Empire is built. Hence it is that Germany could much more rapidly mobilize her armies, with practically no disruption of her internal affairs, in contrast to France, or for that matter any other power, whose instincts for internal development constantly thwarted any ascendancy of a predominating military idea.

After Belgium had been practically subjugated, the concerted action of the German right and center, with their communications fully protected, gave the right wing under von Kluck the opportunity to continue the sweeping movement over northwestern France, to which the French and English could offer but sporadic resistance.

The country over which this movement took place is open and gently undulating, the fields are large and for the most part unfenced, the splendid roads often run in a straight line for many miles, and altogether it is eminently fitted for the operations of large armies. So swift was the onrush, a French offensive could not be developed until August 25, a little less than two weeks after the Germans had begun to menace the northwestern territory. French and English mobilization and concentration could not keep pace with the oncoming Germans.

During this time the allied surgical field work was an extremely arduous, not to say impossible, undertaking. The lines were constantly falling back, which allowed for practically no organization for field hospital work, or even the assembling of the wounded, much less caring for the dead. Scarcely would a regimental stand be made and allow the surgeons to form a hasty plan to group and succor the wounded, when the order would come to fall back. There was nothing to do but apply as many first-aid dressings as practicable to the wounded in the immediate neighborhood of a surgical unit, and then leave them on the field to care for themselves, where those who survived necessarily became prisoners.

On August 25, Gen. Joffre issued an order of the day explaining that as it had been impossible to carry out the projected French offensive, a regrouping of forces would be necessary in order that, by the junction of the Fourth and Fifth French Armies and the British Army, and of forces drawn from the east, a mass of troops might be assembled in the region of Amiens which would be able to assume the offensive in a general direction toward Saint-Pol-Arras or Arras-Bethune. The same order arranged that this extensive movement of troops should be covered by rear guards, whose mission it was to utilize every advantage of ground to stop, or at least to retard, by means of short and violent counter attacks (principally with artillery), the march of the enemy.

From August 25 to September 4, this great movement was carried out, but the rapidity of the advance of the German right wing, coupled with transport and other difficulties and the congestion of the railways caused by the evacuation of Paris, compelled the troops assembling from the east to take positions more to the south than had originally been intended, and the French offensive was consequently delayed. On September 4, reconnoissances by the allied cavalry and aviators discovered that the German right had deflected its march on Paris toward Meaux and Coulommiers. By this time, however, what had been formerly the French left (Fifth Army) was ready to attack the front of the enemy's columns, and it was supported toward the northwest by the British Army and by the army sent out from Paris in taxicabs under Gen. Maunoury, both lying northeast from Paris.

Thus the massing of the forces ordered by Gen. Joffre on August 25 was accomplished. Instead of being enveloped, the French armies were now in a developing position, and the two wings being in contact with the fortified points of Paris and Verdun, the maneuvering of the whole body was greatly facilitated.

It was at this time that Gen. Joffre decided to pass to the attack, and on the evening of September 4 he issued another order of the day, as follows:

> It is advisable to take advantage of the hazardous situation of the First German Army in order to concentrate upon it the efforts of the allied armies of the extreme left. All arrangements will therefore be taken on the 5th in view of an attack on the 6th.

The order of the day then gives detailed instructions as to the forces available and the directions in which they were to attack. The Sixth Army, then northeast of Meaux, was to cross the Ourcq toward Chateau Thierry and the available elements of the First Cavalry Corps were to be placed under the orders of Gen. Maunoury for this operation.

The British Army, established on the Coulommiers front, was to attack in a general direction toward Montmirail, while the Fifth Army, drawing slightly to the left, was to attack from the Esternay-Sezanne front, in a general direction from south to north. The Second Cavalry Corps was to insure communications between these two armies. The Ninth Army was to cover the right wing of the Fifth Army by holding the exits from the Saint Gond marsh and by bringing part of its forces to bear on the plateau north of Sezanne. All these different armies were to assume the offensive with the dawn on September 6. Supplementary orders were issued on September 5 to the French Third and Fourth Armies. They were informed that the French left would attack the First and Second German Armies on the morning of the 6th. They were to act in cooperation, the Fourth Army, stopping its southward movement, to oppose a stubborn resistance to the enemy, while the Third Army was to attack the enemy's left flank, which was marching west of the Argonne.

Finally, on the morning of September 6, Gen. Joffre issued a proclamation, which was not a tactical order, but rather an appeal to the devotion of the troops, as follows:

> At the moment when a battle upon which depends the salvation of the country is about to begin, it is right to remind everybody that now is no longer the time to look back. Every effort must be employed to attack and to drive back the enemy. Troops which can no longer advance must, cost what it may, hold the conquered ground and die where they stand rather than retreat. In the present circumstances no faltering can be tolerated.

This was the beginning of the battle of the Marne, the outcome of which has passed into history as the undoubted salvation of France

and has acclaimed Gen. Joffre a master in the art of war who was equal at the supreme moment to the gigantic task imposed upon him by his country. In view of the events leading up to it and of its decisive character, and in view of the totally different work of the medical department in the subsequent fighting, it is thought to be

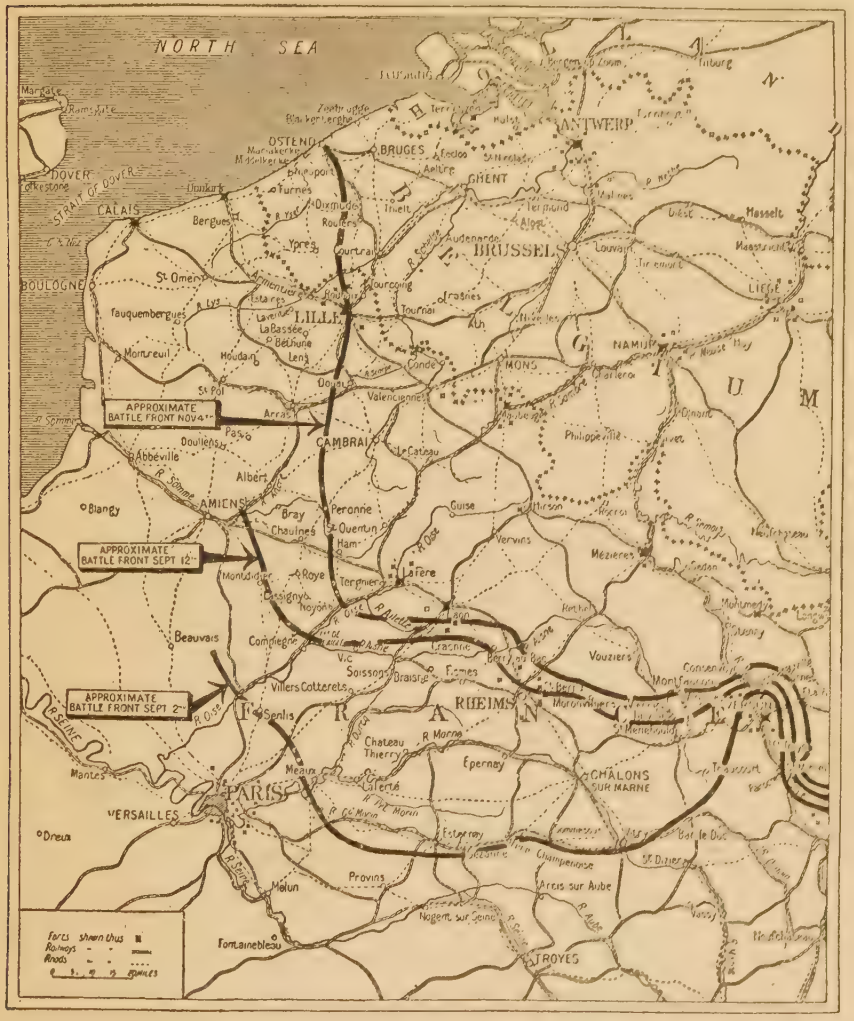

FIG. 1.—Battle front from North Sea to Verdun.

worthy of more than passing notice in the eyes of military surgeons, and that the accompaying map and illustrations will not be without interest.

The Germans lost heavily in their rapid retreat both in personnel and matériel, and finally fell back to the strongly fortified positions which, with few exceptions, they occupy at the present time (Aug.

1915). The character of the fighting again changed when the Germans fell back on their entrenchments, and again the medical department was called upon to meet a totally different problem. The present trench warfare is, with minor differences, practically a siege warfare, and the medico-military problems will be discussed under general fieldwork.

ORGANIZATION OF FIGHTING UNITS.

In order to get an insight into the strength, organization, and utility of the opposing forces in the field it is deemed advisable to offer the following brief outline. If one is to appreciate the medico-military aspect of fighting units there must be some understanding of the composition and division of an average standardized unit, whether large or small.

Infantry is organized into regiments, battalions, companies, and platoons, the strength of which vary considerably in different armies, and at different times in the same army. The standard infantry force may be said to be the battalion, which is now almost always composed of four companies and has the strength of about a thousand men. Some of the German battalions, however, on the outbreak of the war took the field with 1,200 or even 1,500 men. The battalion is commanded by a lieutenant colonel. Each of its four companies (numbering 250 men apiece) is commanded by a captain and subdivided into four platoons (each of about 60 men) commanded by a lieutenant or a second lieutenant.

In the French, German, and other Continental armies a regiment is composed of several battalions, usually three, though sometimes there are as many as six. The battalions of the same regiment in the Continental armies are commonly grouped together, and the whole regiment is commanded by a colonel. In the British Army the battalions of a regiment, which are usually two, rarely serve together, owing to the fact that one battalion in peace time is normally at home and the other on foreign service.

Cavalry is organized into regiments and squadrons. The strength of a squadron is 160 to 200 men, and a regiment is composed of from three to four squadrons. Consequently, a regiment of cavalry may muster anywhere from 400 to 800 men, but 480 men is a fair average strength. To these in the British Army must be added some 60 officers and men, among whom is the machine-gun section with two machine guns.

Artillery is organized into batteries, which are usually armed with six guns and have a strength of about 200 officers and men. The heavy artillery batteries, however, in some armies have only four

guns, but these are of great weight and size. In the Continental armies the artillery is generally grouped into regiments, which include a large number of batteries, usually 10 or 12. In the British Army batteries are grouped into threes in the case of field artillery, and into twos in the case of horse artillery, which are called brigades. The strength of a brigade of field artillery is 18 guns with 795 officers and men. Of these about 200 officers and men form headquarters or are attached to the ammunition column which brings up supplies and ammunition.

The higher organization of troops is into armies, army corps, divisions, and brigades. An army is usually composed of several army corps. Thus Prince Ruprecht of Bavaria, commanding the Sixth German Army, has under his orders four army corps, totaling about 200,000 men. The English troops cooperating with the French in southern Belgium are known as the First British Expeditionary Force, under the command of Field Marshal Sir John French. This force took the field with something over 150,000 men, and there have been numerous acquisitions since, until at the present time (Aug. 1915) there are close to one million British troops in France. This army, which has spasmodically grown since landing in France, has the same general organization as the other continental forces and is now composed of three armies, with the field marshal as commander-in-chief. To these must be added the small Belgian Army, now numbering about 100,000 men, under King Albert, which operates with the British and French forces in southern Belgium. These two groups of troops now hold a fraction over thirty-five miles of the front, while the remaining four hundred and odd miles of the line are held by the French armies, of which there are five in number, having each very close to 300,000 men, with scattered reserves grouped at strategical points in the rear all along the line, numbering about 100,000 men, with reserve munitions and supplies. Gen. Joffre, the French commander-in-chief, is in supreme command of the allied line and of the so-called "zone of the armies," which latter extends back on an average of about thirty-five miles from the first line of trenches.

A brigade of infantry in the British Army is composed of four battalions and has a strength of 4,000 officers and men. In the German, and almost all other continental armies, it consists of two regiments and not fewer than six battalions, so that its strength is 6,000 men or more. A brigade of cavalry consists of two regiments in the Continental armies and in the British Army of three; its strength in either case is about 1,600 men. A division of infantry consists of two brigades in the Continental armies and in the British

Army (fig. 2) of three brigades, with 54 field guns, 18 field howitzers, and 4 heavy guns (long 60-pounders). It has also attached to it engineers, signal-corps men, and transport. In the British service its strength is about 18,500; in the Continental armies it is between 19,000 and 20,000 when the ranks are full.

Two divisions in the British Army make an army corps, which is a force complete with infantry, cavalry, and artillery. Attached to the army corps are usually extra heavy artillery and cavalry, and sometimes additional battalions of infantry and engineers, depending on the character of the operations expected of the particular army corps. The Continental army corps vary greatly in number and strength. A comparison is given in diagram between a British army

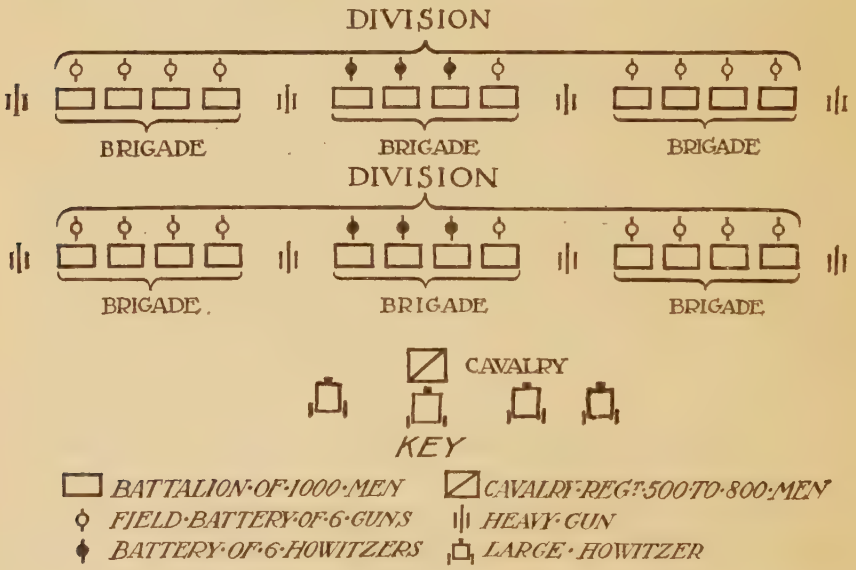

FIG. 2.—Standard unit of a British Army Corps.

corps of standard organization and the Twenty-first German Army Corps (fig. 3), as the latter was organized in time of peace. The Twenty-first Corps was stationed in Alsace-Lorraine, but was later transferred to the Russian frontier. It will be observed that it is distinctly stronger than a British army corps. In the Austrian Army at the outbreak of the war the army corps were even stronger than the Twenty-first German Army Corps, as they each mustered three divisions, bringing them up to nearly 60,000 officers and men, and one or two of them even had four divisions, thus totaling nearly 80,000 men, or the strength of a large army in Napoleon's day. The general opinion is that these overgrown corps have now been split up into more manageable organizations.

At the beginning of the war there was a marked difference in the number of machine guns of the opposing forces, the Germans outnumbering the Allies eight to one. At the present time, one year from the beginning of the war, the machine guns are about equal on both sides in the different units. While shrapnel shells were largely used on both sides during the first months of the war, the Germans quickly substituted the high-explosive shell when the entrenched phase of the battle line began. At the present time the Allies have almost entirely given up shrapnel in favor of the high-explosive type of

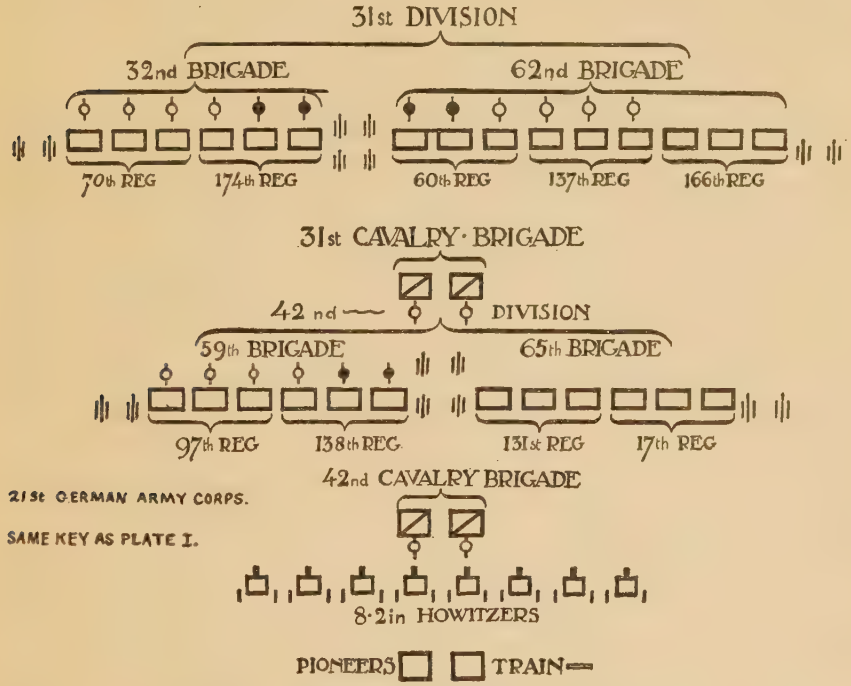

FIG. 3.—Twenty-first German Army Corps.

shell, sometimes including shrapnel, of which a more detailed discussion, and of the wounds they cause, will be presented later on under the appropriate heading.

FIREARMS, PROJECTILES, AND OTHER MEANS OF INFLICTING WOUNDS OBSERVED IN THE PRESENT WAR.

A comparison of the small arms of the belligerents in the western European arena will serve not only to indicate the effectiveness of the weapon under certain conditions, but will throw considerable light on the character of the wounds inflicted; particularly when consideration is given to the character of the fighting as regards range, entrenching operations, open fieldwork and "sniping." Cer-

tain conditions and factors during the present war have led to relegating the rifle to a comparatively insignificant place in the art of maiming or crippling the activity of large groups of men.

The close contact of well constructed and protected opposing trenches, the development of the hand grenade, bomb, high-explosive shell, shrapnel, machine gun, and asphyxiating gas have all combined to greatly limit the usefulness of the rifle in the eyes of the modern military man. There is no doubt of its usefulness, however, in the hands of an alert sharpshooter when a target presents itself either in trench work or in "sniping;" and its moral effect is not to be overlooked as a means of thereby subduing the enterprise of opposing troops in close contact.

As a most valuable and inseparable adjunct to the rifle, after the artillery has prepared the way by breaking up the barbed wire and other obstructions, the use of the bayonet in carrying a position has been a weighty factor during the operations of the present war. The French bayonet, which is triangular on cross-section, needle pointed, fluted and with one or more cutting edges, is considerably longer (4 to 6 cm.) than any of the other bayonets. The English and continental armies employ a knife bayonet which takes the form of their respective hunting knives. According to trustworthy reports from all along the front, the French and English are using their bayonets much oftener and with more deadly effect than the Germans.

	Rifle.				Projectile.					
	Caliber.	Weight.	Sighted to—	Name.	Coating.	Core.	Length.	Weight.	Propelling charge.	Initial velocity.
	Mm.	*Kg.*	*Meters.*				*Mm.*	*Gms.*	*Gms.*	
France.....	8	4.2	2,400	Lebel...	Solid....	Copper..	30.3	13	2.9	700
Germany.....	7.9	4.1	2,000	Mauser..	Steel....	Lead....	28	10	3.2	860
England.....	7.7	3.8	2,540	Lee-Enfield.	Nickel..	....do	32.1	14	2.6	605

These projectiles are fired by a smokeless powder which increases their velocity, and at the present time are cylindro-ogival, having previously been cylindro-conical. The length of the bullet has increased from former times, whereas the weight has diminished. As regards the latter it has fallen from about 25 grams to 13 grams (ball D, French) and 10 grams (ball S, German). The caliber of the rifle has fallen from 11 mm. to about 8 mm, and even to 6.5 mm. (Italy).

The French bullet (ball D) (fig. 8), on account of its high sectional density, maintains a relatively high remaining velocity at extreme ranges. While it is subject to considerable deformation on impact

against a hard substance, and while it produces the characteristic "explosive effect" at certain ranges, it very rarely, if ever, is subject to fragmentation.

The German bullet (ball S) (fig. 9), on account of its lower sectional density, and in spite of its higher initial velocity, is ineffective at ranges at which the French bullet is still dangerous. Ball S, as is the case with all jacketed bullets, not only produces characteristic "explosive effects" at certain ranges, but is subject to deformation and fragmentation when striking hard objects. Fragments of the jacket or contorted forms will often be found in the tissue adjacent to bones shattered by the impact of the bullet. If the point of a jacketed bullet be cut off, or if the bullet be reversed in the cartridge before firing, "mushrooming effects" will be produced, which are very disastrous to tissue (figs. 7 and 10). The lead core of the English and German bullet is uncovered at the large end.

On the other hand, at long ranges, if the bullet has not been deformed by ricocheting or otherwise, comparatively small destruction of tissue is usually noted, as the velocity is very much reduced, causing wounds of entrance and exit of about the same size, or the bullet lodges in the tissues (figs. 11 and 12). Sometimes, although rarely, even at close range, the same phenomenon of small wounds of exit and minor destruction of tissue will be produced, although bone may be fractured. On account of certain conditions and factors, which have never been satisfactorily explained, the bullet at an extreme long range will not infrequently cause wounds showing an "explosive effect"; and hence there seems to be a certain indefinite zone, between short and extreme long ranges, in which the bullet does not produce the marked "explosive effect" usually noted for these two ranges.

The English bullet (fig. 6) is characterized by its very high sectional density and relatively high remaining velocity at extreme ranges. The effects of this bullet are similar to the German bullet, although it is to be noted that it is not as distinctly sharp pointed as the ball "S."

Unless the bullet is deformed by ricochet, strikes sideways, or butt-end-to, it is rare to find particles of clothing carried into the wound, in contrast to shrapnel, shell, and hand-grenade wounds, which are practically always infected from the pieces of clothing and dirt driven deep into the tissues. The effects of rifle-ball wounds of long bones will be seen elsewhere in this report, in connection with the notes under the photographs and X-ray pictures. Penetrating and perforating wounds of the abdomen, brain, and other vital organs will be noted in connection with the report on fieldwork.

There are a number of factors which have a bearing on the character of the wound inflicted by the cylindro-ogival rifle ball, of which

the German ball S is a type. At extreme ranges it is not unusual to find the bullet lodged in the tissues, giving rise to practically no trouble unless situated in a particularly sensitive region. If the soft parts only are involved, the wound of entrance and the channel are of the same size as the undeformed bullet. In general terms, it may be said that the closer the range the less liability there is of the bullet lodging in the tissues and the greater the tendency to exhibit "explosive effects" in the wound. Thus, when there is a wound of entrance and exit the latter is usually larger at close ranges and the track of the bullet through the tissues is funnel shaped, with the small end of the funnel at the wound of entrance. This is due to two factors: First, the inability of the tissues to separate quickly enough to allow the high-velocity bullet to make a channel without pushing some of the tissue it traverses ahead of it and thus enlarging the channel toward the wound of exit; secondly, when compact bone is in the path of the high-velocity bullet it almost invariably causes a certain degree of comminution and the smaller bony fragments act as secondary missiles to enlarge the channel toward the wound of exit. When comminution of bone takes place it is also usual to find many of the smaller pieces driven deep into the tissues adjacent to the bone.

As not infrequently happens, a bullet may be deflected from its original course by contact with the denser tissues, such as fascia, cartilage, or bone, and when a bullet "tumbles" in its flight, causing a lateral or butt-end impact, the character of the wound of entrance is different than when the tissues are penetrated by the sharp end of the bullet. The larger the surface of the bullet exposed to impact the greater will be the immediate destruction of tissue, though the penetrating effects will be greatly reduced, and thus a bullet may even lodge in the tissues at comparatively close ranges.

When a rifle bullet, such as the German or English, becomes deformed by striking a hard object before actually penetrating the tissues, the outer coating of nickel steel may become distorted, and even entirely separated from its core of lead, upon impact with the body, and there may be fragmentation of both jacket and lead core, causing a lacerating and destructive wound of the deeper tissues (figs. 15–17).

The contact of a high-velocity bullet with dense bone not infrequently causes deformation and fragmentation of the bullet and usually comminution of bone. The cancellous ends of long bones are usually perforated without fragmentation or splintering. While the splintering or comminuting effects of the high-velocity bullet on the shaft of long bones may sometimes take the form of specially descriptive fractures, such as "butterfly," "stellate," etc., it very frequently happens that there are no special lines of cleavage to be noted but

simply an irregular comminution. The French bullet (ball D) being solid copper, as already indicated, does not undergo fragmentation.

A bayonet wound is a penetrating or cutting stab wound usually of the abdomen, chest, or groin, and in not a few instances is multiple. The character and result of this wound will be mentioned later in connection with fieldwork. Sabers are used for thrusting or slashing, and the wounds they inflict are usually multiple. The saber wound is usually in the region of the head, right elbow, and left upper arm. The cavalry lance is a long thrusting implement propelled with considerable force and aimed at the trunk. The French lance has a head of quadrangular section, 15 cm. long and 2 cm. in diameter. The German lance has a triangular head 30 cm. long and 15 mm. in diameter. Lance wounds are almost invariably in the trunk. As the bayonet, saber, and lance are only used in hand-to-hand conflict, which is a particularly ferocious kind of fighting, the fatality accompanying these wounds can readily be understood, since it is usually a fight to the finish between the troops engaged. Wounds from these thrusting implements have tended to increase as the war has progressed. In 1870 there were only 600 cases of thrust wounds out of 98,000 wounded (Delorme), while at the present time Gen. Delorme, of the French medical service, estimates that they comprise 5 per cent of all the wounds.

Pistol wounds in this war are extremely rare. The French and German officers are provided with an automatic pistol of the same general type as is provided in the American Army. In instances where these wounds have been treated they have shown a marked "explosive effect," especially when bones were involved.

Thin steel helmets are now universally used by the Germans in the trenches. The French cavalry have also worn this form of headgear for many years, together with a thin steel cuirass protecting the chest and abdomen. The French have adopted a steel helmet 7 mm. thick, which is now being worn by their troops in the trenches. It is believed that it will considerably limit the number of head wounds in the present character of fighting.

GRENADES.

The offensive by sapping has brought the Allies' and German lines, in the present trench warfare, into very close contact. In some instances the opposing trenches are only 5 to 10 meters apart. The depth of the trenches and the protection they afford are such as to render rifle fire of very little value in storming the occupants. Since the trenches are so close together in the first line that neither side can use artillery freely without greatly endangering their own troops,

grenades have assumed a very important rôle in this character of fighting, and so much so that at the present time under certain circumstances, they are the principal means of putting a section of trenches out of action. On this account, and on account of the severe wounds they inflict, their use and study is of special interest to the military surgeon.

When the opposing trenches are farther apart an infantry attack can be delivered with minimum loss if the barbed-wire and other obstructions have been destroyed by intense artillery fire and by the explosion of mines in connection with sapping operations. In this manner breaches are made in the accessory defenses and allow the charging troops to reach the enemy trench. To put out of action quickly the last defenders of the trenches attacked part of the assaulting troops are provided with hand grenades or bombs. These missiles are thrown at the enemy over the barriers that may have been erected and into the firing and connecting trenches, all parts of which it has not been possible to capture at once.

There are several types of grenades in use by the opposing forces which are furnished the troops in the field. In addition to these the troops themselves extemporize various kinds from the material to be found at the front. The hand grenade furnished to the French troops is the bracelet type (figs. 18 and 19), with automatic firing mechanism, consisting of a ball of cast iron filled with a high explosive and of a leather bracelet fastened to the wrist. To the bracelet is attached a rope about a foot long, having an iron hook at the end. Just before throwing the grenade the hook is engaged in the ring of wire attached to the friction primer forming a part of the fuse plug which closes the iron ball. Thus when the grenade is thrown the ring of wire and friction primer are wrenched off and the fuse is fired. This grenade can be thrown about 25 meters, and explodes four or five seconds after the primer has been released.

The German grenade can be thrown by hand or rifle (figs. 20, 21, and 25). By hand it is used for short distances, 15 to 20 meters. It is composed of a copper rod to the extremity of which is fixed a cast-iron cylinder filled with a high explosive and grooved in order to facilitate its breaking into small pieces at the moment of explosion. A copper tube, also containing some explosive, is placed in the interior. It is surmounted by a complicated system for closing the grenade and for automatic firing by percussion, which is said by the French to result in a large percentage of misfires. In quite a number of instances the British troops have hurled back these grenades into the German trenches. Used with the rifle, this grenade has a maximum range of 400 meters. When so used a blank cartridge is placed in the chamber of the rifle and the quantity of powder left in the car-

tridge is regulated according to the distance to be thrown. The Germans, like their opponents, make use of a large number of extemporized grenades. The assaulting troops carry them in haversacks or strung in a circle of wire around the shoulder or waist (figs. 22–26).

The grenade wounds, besides the usual great destructive effects (fig. 23), are always infected wounds, the fragmented casing carrying into the tissues particles of clothing and dirt, and resembling in this and other respects the shrapnel and shell wounds. It would be difficult to estimate the range of effectiveness of a fragmented grenade since their use only contemplates an explosion at close quarters in a restricted area, such as the modern zigzag and communicating trench. Hence it is that only the occupants of a small section of trench are injured by the fragmented projectiles. These weapons exert a considerable moral effect owing to the violence of the explosion and the great mutilation of face and body which they occasion. A premature explosion of the manufactured grenade is prevented by rendering it innocuous except in the act of throwing, which latter releases the safety pin or ring and either starts the fuse burning or converts the grenade into a contact explosive, causing the charge to burst on impact with earth, water, or snow.

The *minenwerfer*, or trench mortar, first introduced by the Germans in the early fighting around Ypres, is another means of hurling a large amount of high explosive into an opposing trench. As used by the Germans, it is said to have a range of 350 yards and throws a thin-walled shell weighing 187 pounds, the latter having an explosive effect only. In construction it is built along the lines of a catapult and light enough to be drawn by two men. In addition to this weapon, crude arrangements have been employed on both sides to throw a large charge of high explosive for the purpose of destroying barbed-wire entanglements and other obstructions. The underground (sapping) trench has also been used extensively for the same operations on a larger scale. Aerial bombs, either incendiary or high explosive, are likewise used, principally for the bombardment of supply depots, railroad stations, and towns. The French aviators also drop steel darts on troops in the open. These darts are about the size of a pencil, 5 inches long, sharp pointed, and grooved so as to keep the missile vertical in flight. A thousand darts are dropped at a time from a great height and are said to scatter over an area of 200 yards.

MACHINE OR RAPID-FIRE GUN.

While the rifle is still the infantryman's principal weapon, the machine gun is playing an increasingly important rôle in the conduct

of the present war. At the beginning of the war the Allies were markedly deficient in this arm, but at the present time there seems to be no advantage on either side in this respect. Organized rifle fire is directed in various ways, according to the conditions to be met. Thus we have "distributed frontal fire" along the entire line of an advancing body of men; "concentrated fire" on a particular spot for a definite reason; "oblique fire" from one portion of a trench while the other portion is occupied in the assault; "enfilade fire" when a trench or body of men is fired upon from their flank; and "covering fire" when reserve troops situated on high ground fire on the enemy trench over the heads of their comrades in front.

The rapid-fire gun, while not a new idea, has been greatly improved upon since Dr. Gatling's American Civil War invention. It is far superior to the rifle for repelling a charge, either by direct or enfilading fire, in defending trenches. While normally mounted on a tripod and manipulated by two men, it is also being largely used mounted on a motorcycle or autocar for a reconnoissance in force.

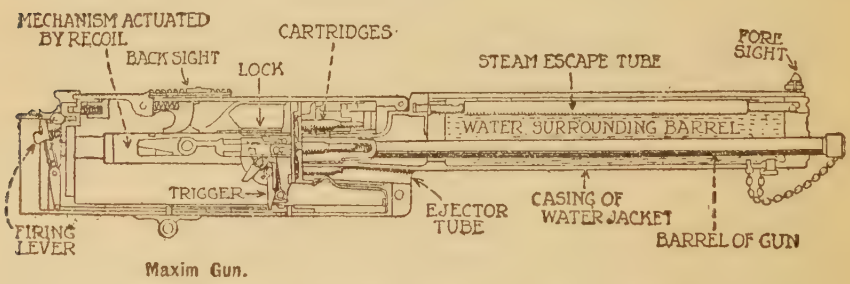

FIG. 4.—Showing longitudinal section of a Maxim machine gun.

The Maxim machine gun (fig. 4) is the type used by all at the present time, each country having a slight modification of its own. It has a single barrel which is kept cool by either a water jacket or by air radiation, and is entirely automatic in its action. This latter means that after the first shot it will continue to fire at a very rapid rate (400 to 550 shots a minute), all the necessary operations of loading and firing being worked by either the recoil or by the pressure of the exploding gases within the barrel. They are built to take only the regular service rifle cartridge used by the troops, and these are fed to the gun by means of a belt carrying usually 250 cartridges. Although the entire gun, which can be easily folded for transportation, weighs only about 70 pounds, yet one great drawback to its more general use is that it consumes an enormous quantity of ammunition. It also requires two specially trained men to operate. The wounds caused by this gun are, of course, the same as those from the service rifle.

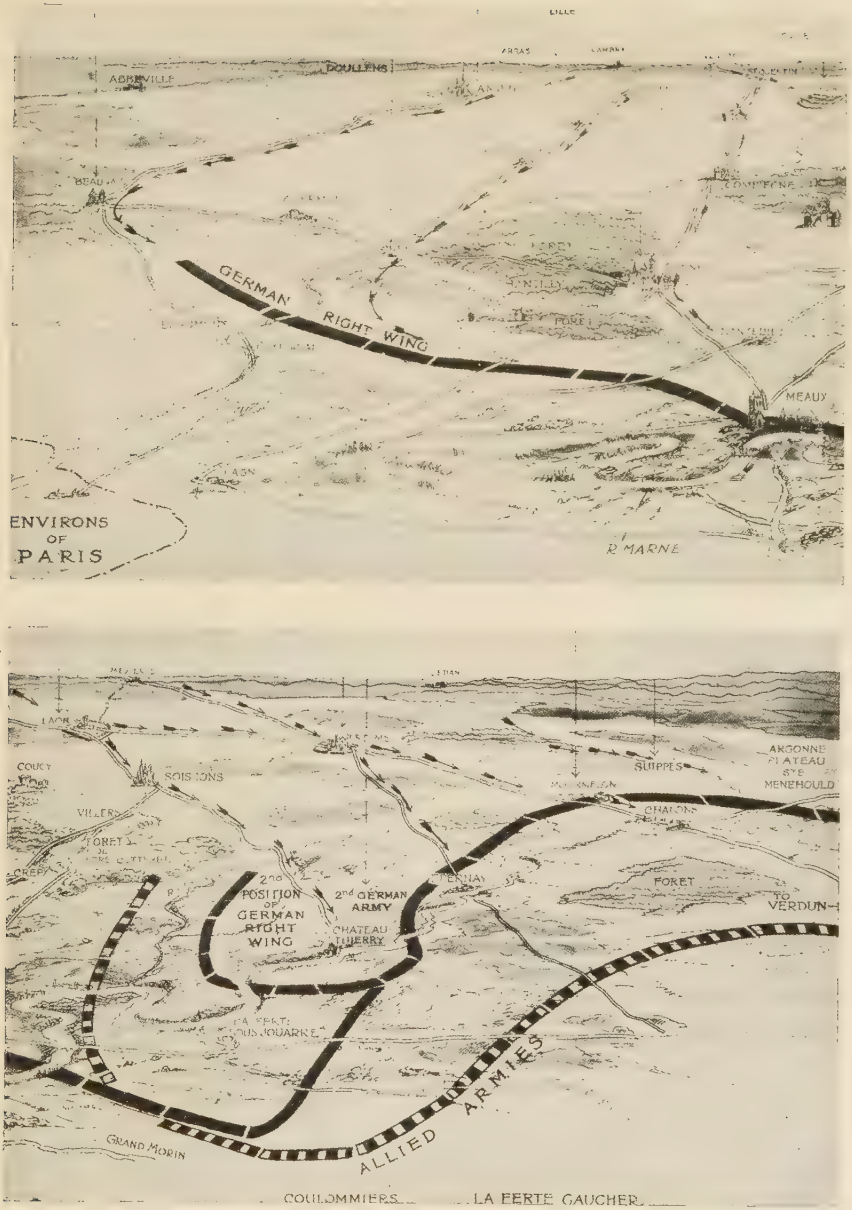

FIG. 5.—DIAGRAMMATIC BIRD'S-EYE VIEW OF THE ADVANCE OF THE GERMAN ARMIES ACROSS THE PLAINS OF FRANCE TO THE TURNING POINT ON THE MARNE.

The Allies retired in the first week of September, 1914, before the advance of the Germans, along the main roads indicated by the black arrows. From Cambrai the Germans pushed through Amiens to Beauvais about September 2. From Peronne they marched on to Roye, Montdidier, Creil, and the Forest of Chantilly. From the region of Le Cateau and St. Quentin the advance was by Noyon to Compiègne, at which point they had to fight for every inch of ground. They then passed through Senlis down to Meaux. Laon, though heavily fortified, was relinquished by the Allies during their retirement; and the enemy advanced thence to Soissons and Chateau Thierry. Farther to the east the invasion from Mézières passed by Rheims to Épernay, Mourmelon, and Châlons. Another force coming from the direction of Longwy appeared to be operating through Suippes and on the wooded Argonne Plateau, with its five passes famous in the action in 1792 which preceded the dramatic battle of Valmy. The vertical arrow lines signalize the points of importance in the German advance.

Fig. 6.—Actual size of English cartridge. (See page 11.)

Fig. 7.—Wounded (200 meters) while running, showing smaller wound of entrance and larger (explosive) wound of exit, causing multiple fracture of tarsus and opening up the ankle joint. (See page 11.)

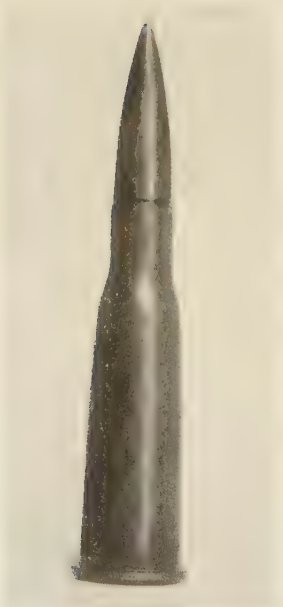

Fig. 8.—Actual size of French cartridge "D." (See page 10.)

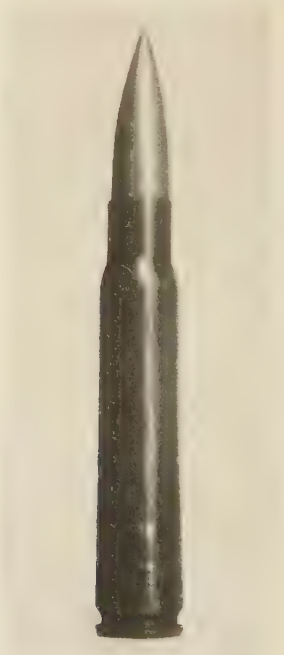

Fig. 9.—Actual size of German cartridge "S." (See page 11.)

Fig. 10.—Bullet striking jaw at close range (30 meters), causing multiple (explosive) fracture, with considerable loss of substance, and continuing on through neck and shoulder. (See page 11.)

Fig. 11.—Wounded at something over 1,500 meters, through soft parts only. Entrance and exit about the same. (See page 11.)

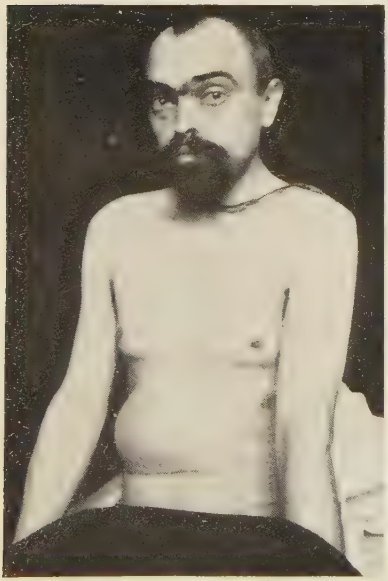

Fig. 12.—Wounded at medium range. Entrance over ninth rib, midaxillary line, right side. Exit over sixth rib, left side anteriorly, causing rupture of right rectus muscle and quick development of large ventral hernia. Abdominal cavity not entered. (See page 11.)

Fig. 13.—Wounded at extreme range. Entrance just above right zygoma and 2 cm. in front of tragus, passing beneath both eyeballs and lodging in the body of left malar bone, just beneath the skin. Practically the only symptoms were a periodically persistent nose bleed and extreme tenderness over left malar bone. (See page 11.)

Fig. 14.—Shows X-ray picture of undeformed ball lodged in left malar bone of same case as figure 12.

Fig. 15.—Showing loose fragments of bone in rifle-ball wound of forearm. Fragments were driven a considerable distance into surrounding tissue. (See page 12.)

Fig. 16.—Showing varying degrees of deformity and fragmentation of the German bullet "S" which were removed from different parts of the body. (See page 12.)

Fig. 17.—Showing X-ray of rifle-ball wound of middle of arm, and the deformation and fragmentation of lead core and steel jacket of a German ball "S," with great comminution of bone and marked secondary missile effect. The drainage tube shown in the picture was introduced at a field hospital after removing the first-aid dressing. This wound occurred at close range. (See page 12.)

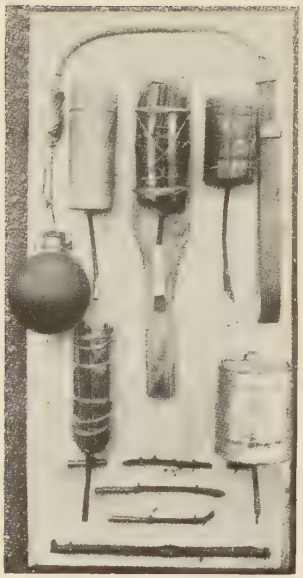

Fig. 18.—Showing the regulation French bracelet type of hand grenade and a number or extemporized types, such as the "racquet" and "jam-tin." (See page 14.)

Fig. 19.—Showing a French soldier in the act of throwing a grenade. (See page 14.)

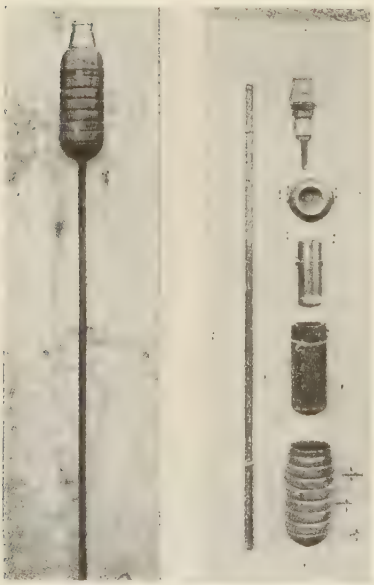

Fig. 20.—Showing German combination grenade. (See page 14.)

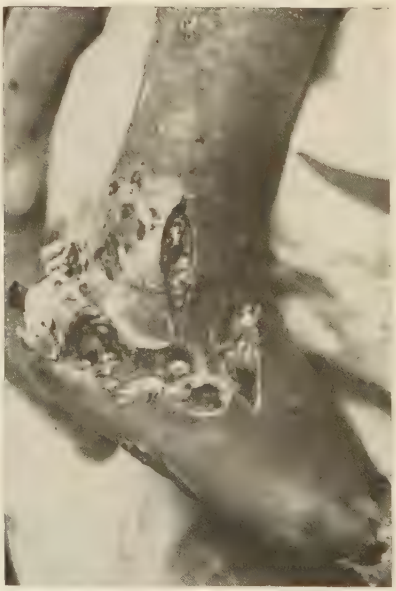

Fig. 21.—Showing grenade wound of right foot, from which the fragments in figure 20 were removed at base hospital after preliminary operation in field hospital. (See page 14.)

Fig. 22.—English combination grenade used in a rifle. (See page 15.)

Fig. 23.—Showing great mutilating effect of grenade wound of face with loss of right eye. (See page 15.)

Fig. 24.—English combination grenade. (See page 15.)

Fig. 25.—Showing actual size of fragments of a German grenade removed from foot. (See page 15.)

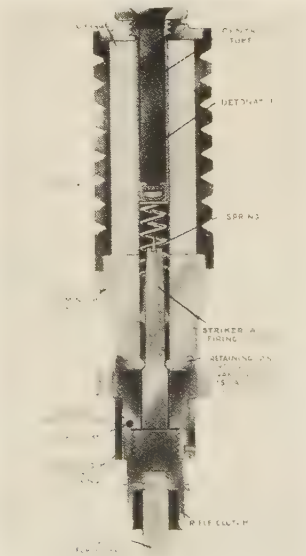

Fig. 26.—Longitudinal section of a recent grenade invention used by the English. (See page 15.)

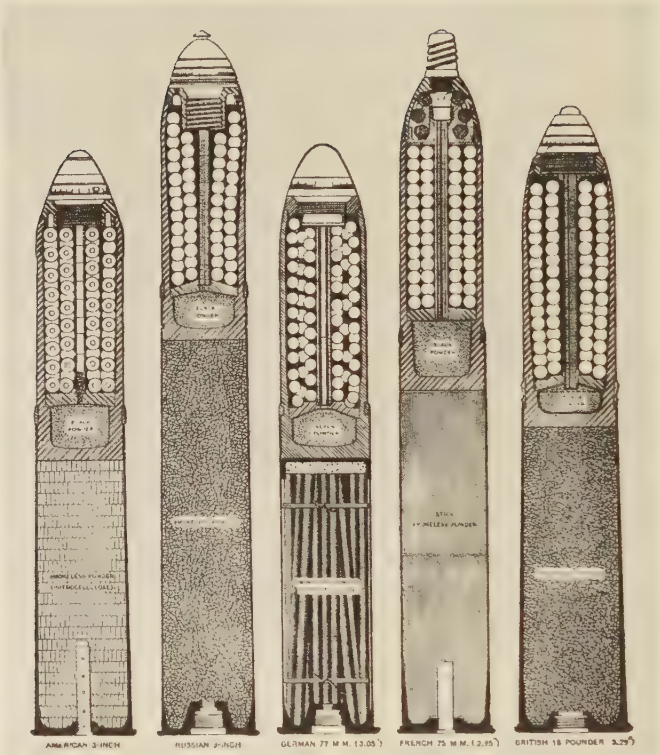

Fig. 27.—Types of shrapnel in modern use.

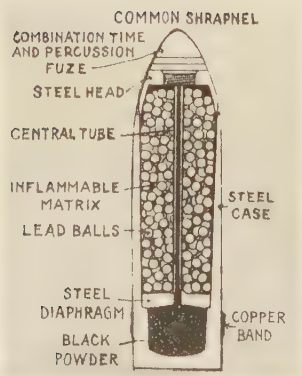

Fig. 28.—Common shrapnel.

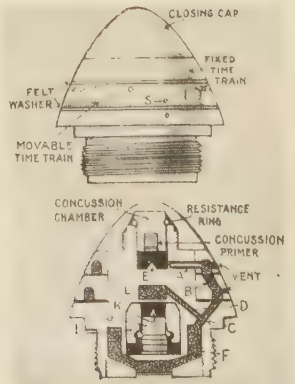

Fig. 29.—Fuse used in common shrapnel. (See page 22.)

Fig. 30.—Actual size of shrapnel bullets, pieces of shell, and a German bullet (upper right-hand corner) removed from wounds, and (lower left-hand corner) an English and French bullet for comparison. (See page 23.)

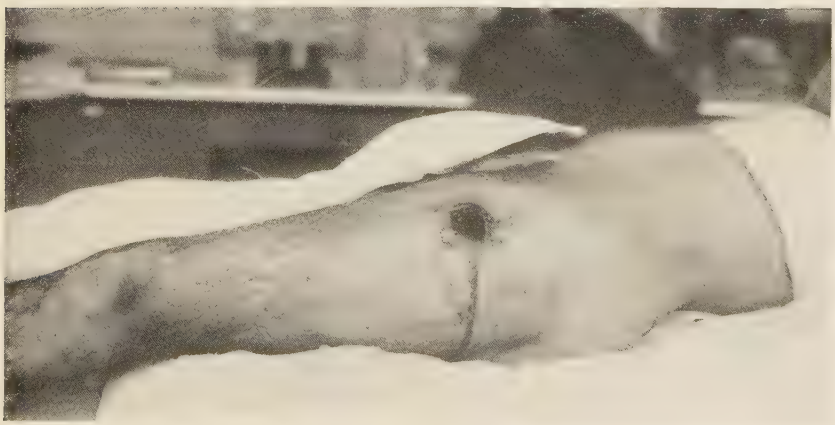

Fig. 31.—Penetrating shrapnel wound of thigh with fracture of femur. (See page 23.)

Fig. 32.—This illustrates a shrapnel wound of right arm with considerable destruction of tissue and loss of substance. (See page 23.)

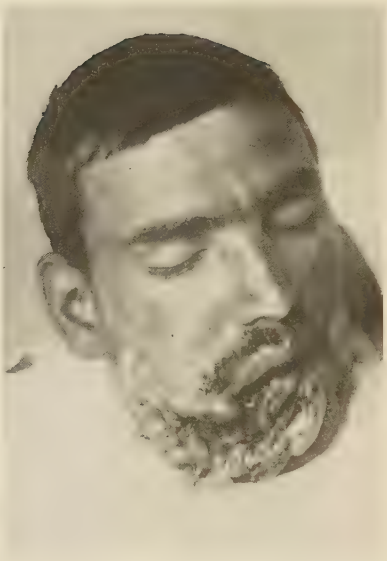

Fig. 33.—Shrapnel wound of face, with multiple fracture of lower jaw and considerable loss of substance. (See page 23.)

Figs. 34–35.—Showing front and side views of high-explosive shell wound involving entire loss of lower jaw and great destruction of tissue. (See page 24.)

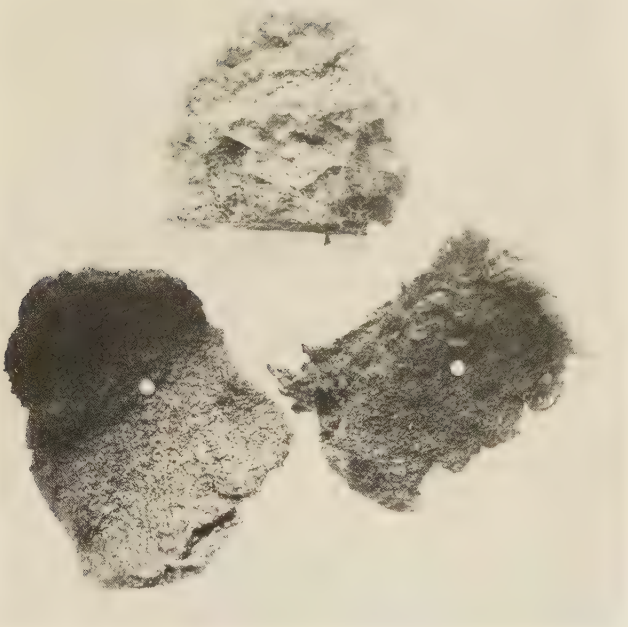

Fig. 36.—Actual size of piece of shell (above) and two pieces of cloth (below) removed from a shell wound of the back, showing some fibers of clothing still clinging to piece of shell. (See page 24.)

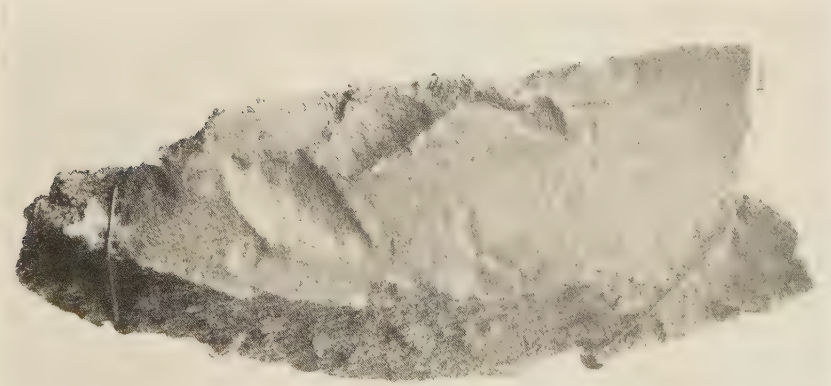

Fig. 37.—Actual size of fragment of high-explosive shell removed from lower jaw. (See page 24.)

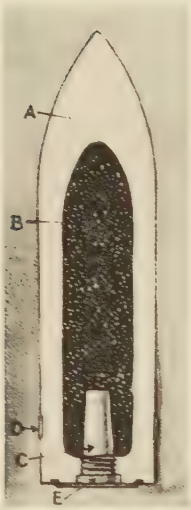

Fig. 38.—A high-explosive shell in cross section. (See page 24.)

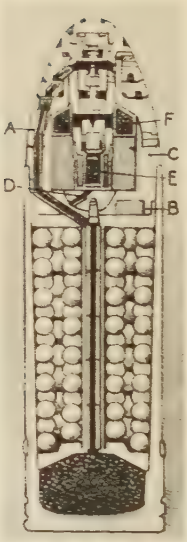

Fig. 39.—A type of the high-explosive shrapnel. (See page 24.)

Fig. 40.—Smaller fragments of high-explosive shell (actual size). (See page 24.

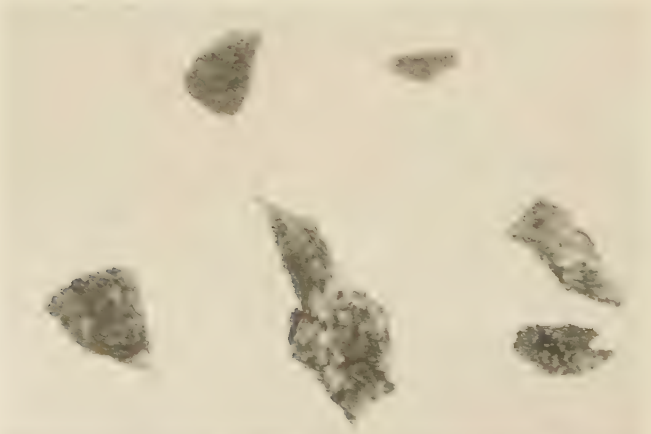

Fig. 41.—Small pieces of shell casing and fragments of bone (below), removed from arm. (See page 24.)

Fig. 42.—Compound comminuted fracture of elbow joint, with great loss of substance, the result of a high-explosive shell wound. (See page 24.)

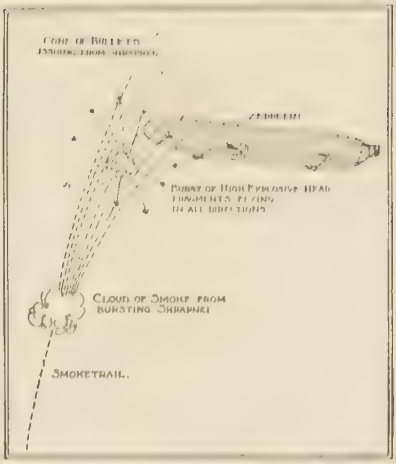

Fig. 43.—Generally considered the best projectile against Zeppelins; a high explosive "universal" shell bursting, with fragments flying in all directions. (See page 25.)

Fig. 44.—High-explosive shell wound of right shoulder, with entire loss of deltoid muscle and complete shattering of upper half of right humerus; but the larger blood vessels and nerves were uninjured. The wound was infected and there were numerous large sloughs in different parts of the wound. Received four days after receipt of injury, and first dressing had not been removed. A large number of small fragments of bone were removed in this case. Under wet dressings and overhead extension the wound rapidly cleared up; the patient was completely comfortable and could be dressed without pain. (See page 24.)

Fig. 45.—X-ray picture of preceding case, showing the destructive effect on the humerus and small particles of shell and bone in wound.

Fig. 46.—A French "75" cannon which passed through seven months' campaigning.
(See page 26.)

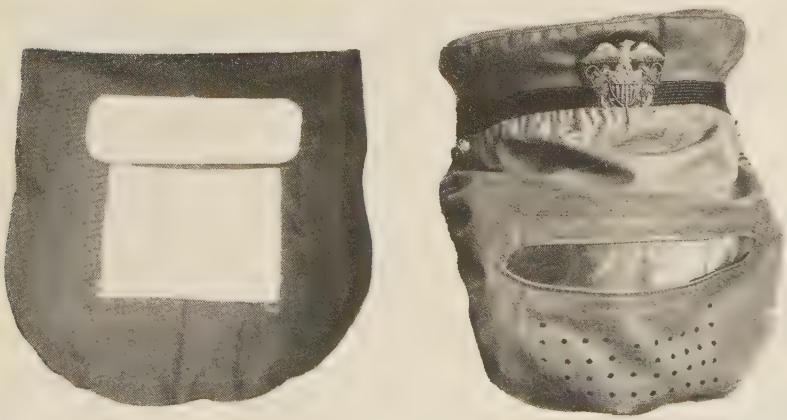

Fig. 47.—One form of mask fitted on cap to the right and pattern of mask to the left.
(See page 28.)

ARTILLERY.

The artillery used by the opposing forces, with the exception of the light fieldpieces, has been undergoing various changes since the war began, to suit the varying conditions along the entire front. In the early part of the war, with the exception of the large siege guns and mortars used to reduce the Belgian fortifications, the light mobile field guns were almost exclusively used on both sides. These were the 75-mm. of the French, the 77-mm. of the Germans, and the 3.29 inch of the English. Shrapnel was largely used in these projectiles at that time, as the present obstructive and trench warfare did not develop until the German retreat and entrenchment after the battle of the Marne. Besides the field artillery mentioned, the French are now using a 90-mm., 105-mm., 120 mm., 155 mm., and a 220 mm. long and short. The heavier guns of the Germans are the 105 mm., 130 mm. (light howitzer), 150-mm. (heavy howitzer), 210 mm. (light mortar), and the heavy siege guns, 380-mm. and 420-mm. The English (in addition to the 3.29-inch) are using a 5-inch (120 mm.) howitzer and several higher caliber naval guns mounted for land operations.

While the larger cannon are used on both sides for long range work and for special reasons, the "75" (French), "77" (German), and "3.29" (English) have been by far the most generally used throughout the war. The reason for this is on account of the superior mobility and quick-firing feature of these pieces. There has been a good deal of rivalry during the last decade, in the different countries, in developing superiority in the light fieldpieces, and while the general mechanism of each is about the same, there are certain minor differences which each country thought the best, which changes were closely guarded. The recoil after firing in each of these fieldpieces is taken up almost entirely by a combination hydraulic and hydropneumatic system, which prevents the recoil being transmitted to the carriage, and the latter therefore does not have to be put into position after each shot. This arrangement admits of quick firing with accuracy.

BALLISTICS.

As there is no doubt that the field artillery is playing the dominant rôle in the present war, it is thought that a few words and sketches on ballistics would not be out of place. This is to be followed by a description of the projectiles which cause the great majority of the mutilating wounds, and therefore should be of interest to the surgeon. Ballistics is that portion of the science of gunnery which relates to the motion of projectiles. Interior ballistics relates to the motion of the projectile in the bore of the gun, and until the maximum of

initial velocity is attained. Exterior ballistics relates to the motion of the projectile from the muzzle of the gun to the point of fall or impact.

Interior Ballistics (fig. 48).—A 3-inch 50-caliber quick-firing gun is shown in vertical longitudinal section, with the projectile in its position at the moment of discharge. Upon the ignition of the powder charge, the combustion of the powder proceeds with regularly increasing velocity, evolving gas under high pressure, which exhausts its energy in imparting motion to the projectile. As the projectile moves along the bore of the gun, the space containing the gas increases until a point is reached at which this space exactly compensates for the evolution of the gas and this is the point of maximum pressure (curve A). From this point on the pressure of the gas upon the base of the projectile decreases until the projectile

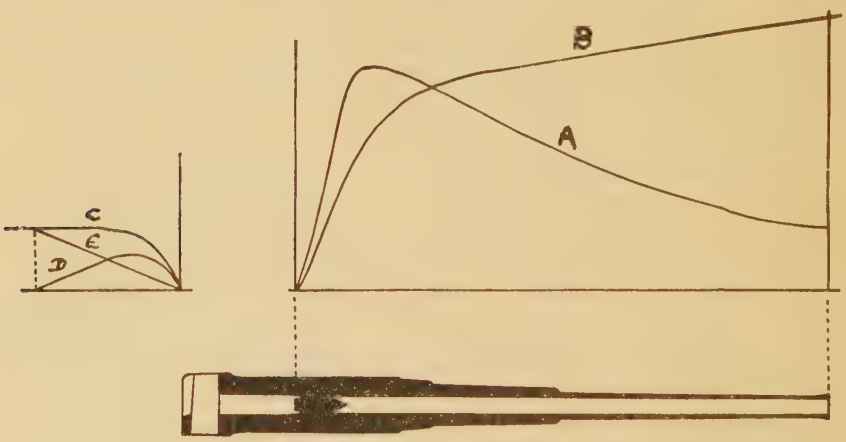

Fig. 48.—For description see text.

leaves the muzzle. The projectile starting from rest (curve B) acquires velocity first with increasing and then with decreasing acceleration until a short distance beyond the muzzle, where it attains its maximum or initial velocity. During this motion along the bore of the gun, the projectile is in engagement with the rifling which latter forces it to revolve about its longitudinal axis, this rotation being necessary to insure stability of the projectile during flight. Action and reaction being equal and opposite, as the projectile moves forward under the impulsion of the powder gas, the gun, due to similar pressure upon its breech block, recoils and if left free would attain a maximum velocity proportionately less than that of the projectile on account of its greater weight (curve C). The recoil is checked by hydraulic and hydropneumatic brakes which offer uniform resistance (curve E), and the gun is brought to rest on its carriage after a fixed length of recoil (curve D).

The curves of pressure and velocity (A and B) may be determined by a variety of methods and by the employment of a variety of instruments. If either be determined experimentally, the other may be derived from it by computation. These curves are only of interest, however, in connection with problems of gun construction. crusher gage (fig. 49). This consists of a steel cylinder A, in which is placed a copper cylinder B of known dimensions, held between a gas-tight piston O and the base of the cylinder. The gage is inserted in the powder charge and is subjected to the pressure of the powder gas. The result of the gas pressure is to crush the copper cylinder to a length C proportional to the pressure. As the reduc-

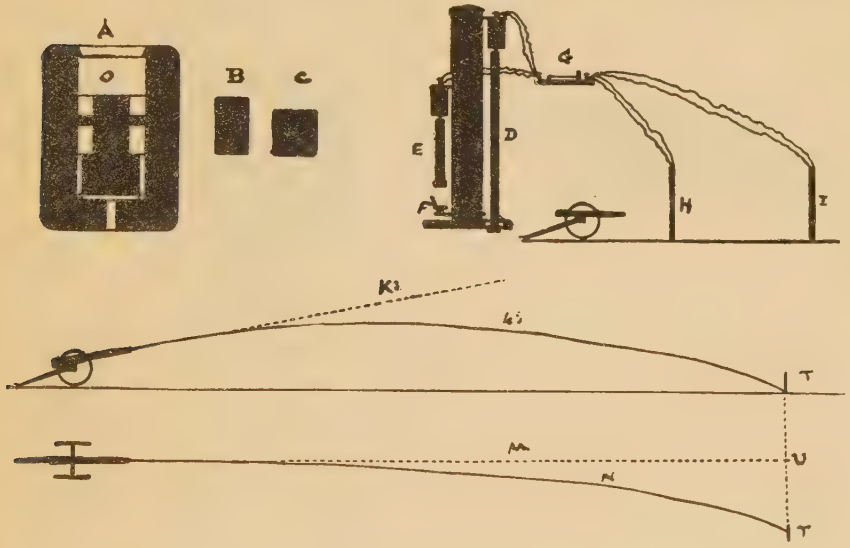

Fig. 49.—For description see text.

tion of length of the copper cylinder for any given pressure may be determined experimentally, a simple measurement of its final length will disclose the maximum pressure in the chamber of the gun.

The initial velocity is determined by means of the ballistic chronograph (fig. 49). In this instrument a rod D is suspended from an electromagnet, the induction coil of which is in circuit with a wire screen H, placed a few yards in front of the muzzle of the gun. A second rod E is suspended from an electromagnet in circuit with a second screen I at a given distance, say 50 yards beyond H. When the gun is fired the projectile traverses the first screen H, breaking the circuit and releasing the rod D. When the second screen is traversed the rod E is released, and when it strikes the trigger F a knife is released, which makes a mark on rod D, thus indicating the

distance fallen during the flight of the projectile between the two screens. A device, known as the "disjunctor" G, permits both circuits to be broken simultaneously, with a corresponding mark on rod D, which gives the distance fallen during the time taken by the rod E to strike the trigger F and for the knife to strike the rod D. The distance between the two marks being measured, the laws of falling bodies enables the time of fall to be determined, and hence the time required by the projectile to traverse the distance from H to I; this distance divided by the time gives the velocity of the projectile midway between the screens H and I.

Exterior Ballistics (figs. 49 and 50).—Were a projectile fired *in vacuo*, and were the force of gravity absent, the projectile would

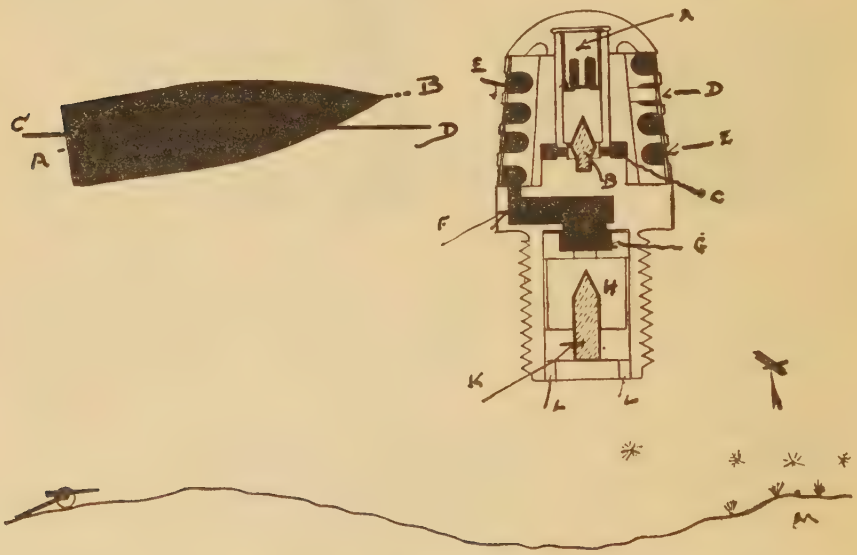

Fig. 50.—For description see text.

move indefinitely in a straight line K (fig. 49), according to its initial velocity. The resistance of the air, however, constantly reduces the velocity of the projectile and the force of gravity, in accordance with the law of falling bodies, constantly draws it away from its initial direction, with the result that the projectile describes a parabolic trajectory, striking the earth at the point T. As the projectile leaves the gun with a high velocity of rotation about its longitudinal axis, it is in fact a gyroscope, and its axis AB (fig. 50) tends to remain parallel to its initial direction and makes an angle with the trajectory CD. At the same time the phenomenon of precession causes the axis to rotate slowly, describing a cone about its initial direction. Nearly all guns are rifled with a right-hand twist, and the projectile therefore rotates, viewed from the rear, in the direction of the hands of a watch, and the precession is in the same direction. In flight, there-

fore, the axis of the projectile is inclined upward and to the right of the trajectory, with a result that the resistance of the air acts on its under and left surface. This unbalanced pressure produces the phenomenon of *drift*, with the result that the projectile, instead of following the straight line M (fig. 49), curves to the right, striking the target T to the right of the point U. This drift is compensated for by the deflection slide of the sight.

The sketch at the bottom of figure 50 is intended to show one of the simple methods of striking an object M at an unknown distance from the gun. Suppose the range is estimated to be about 3,500 yards. The sight is set at 3,200 yards and a shot is fired. An observer (in aeroplane or in some position permitting him to see the burst of the shell) reports that it has fallen short. A second shot is fired at 3,600 yards and is reported over. The target is therefore between 3,200 and 3,600 yards from the gun. A third shot is fired with the sight at 3,400 yards and falls short; the range is now known to be within 3,400 and 3,600 yards, and so on until the observer reports the range is correct. With time fuses the distance may be determined by assuming the time of flight to the target, increasing or diminishing this as the burst of the shrapnel is short or over, dividing the difference between the assumed time for the third shot, and so on until the range is obtained. When the target is visible from the ground a range-finding instrument is used when practicable to control the fire.

Combined Time and Percussion Fuse (fig. 50).—This type of fuse head is used almost exclusively with shrapnel, a simple percussion fuse being employed with the explosive shell. The fuse shown is similar to the service French shrapnel fuse, but differs in certain details. This fuse is screwed into the point of the shrapnel, and upon discharge of the gun, the plunger A drives down upon the pin B. The fulminating compound in the plunger detonates, igniting the ring of powder C. The gas evolved blows through the hole D, igniting the train of compressed powder E, which is wound in a spiral about the body of the fuse. The time train burns slowly until the flame reaches the magazine F, when the latter explodes, driving the flame through the channels LL into the body of the shrapnel and igniting its bursting charge. By means of a special tool the hole D may be pierced at any point of the length of the time train, thus causing the shrapnel to explode within one-tenth of a second of any given interval of time. The percussion arrangement is lodged in the stem of the fuse, and upon discharge the lead plunger H rides down on the firing pin K exposing the point of the latter. Should the projectile strike a resisting object before the time train has caused its explosion the plunger will drive forward, strike, and detonate the

primer G. This will ignite the magazine F, which will cause the explosion of the shrapnel.

The stability of the French field gun, "75," is shown in figure 51. The shaded square back of the breech is the point to which the barrel of the gun recoils after firing. The pointed spade at the end of the trail is forced into the ground after the first shot and, with the hydropneumatic brake system (shown under the barrel), takes up the entire recoil. In addition to this, there is a metal brake for the gun-carriage wheels with a spike on the under side. This brake is made to slide on the rim of the wheel, and when the gun is stationary the wheels rest on the brake and thus force the spike into the ground.

The use of the quick-firing fieldpiece has become of such paramount importance in the present war as to warrant a close scrutiny of the projectiles in use by the opposing forces, and in this study the surgeon is especially interested. in that by far the greater number of

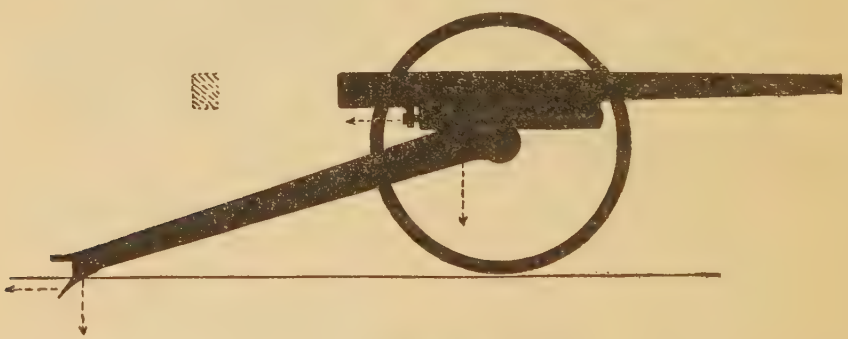

FIG. 51.—For description see text.

serious wounds are inflicted by the different types of shell used in these guns (fig. 27).

It will be seen that there is very little difference in construction of the shrapnel shell and case in those employed by the various countries. The form of the propelling charge held in the brass case differs in almost every instance, but without exception smokeless powder in some form is used. In the American shell nitrocellulose smokeless powder is used in perforated cylindrical grains; in the Russian and British shell a crystalline form of smokeless powder is used; in the German case the smokeless powder is compressed into long sticks and arranged in bundles, while the French also use a smokeless powder compressed into thin strips (fig. 28).

A description of the French fuse head for common shrapnel has already been given, and it only remains to discuss briefly the working of a typical fuse in use by the other four powers, as shown in figure 29. As the projectile is driven down the bore of the gun the inertia of the concussion plunger causes it to slip through the re-

sistance ring and strike the pin E, which explodes the percussion primer. The flame of the primer passes through A and ignites the fixed time train. To increase the length of the time train it is usually made in two parts, as shown, one of which is contained in a movable ring, and by turning this the time of burning is regulated. In the typical fuse the annular train burns from the point of ignition hole A until hole B in the movable train is reached. The movable train is then ignited through B and burns back to fixed hole C, communicating with magazine F. The greater the annular distance between hole B and hole A, the longer the fuse will burn before explosion. By setting the movable ring so that B is opposite A, flame is at once permitted to pass through B and C and the projectile is exploded within a few feet of the muzzle. A simple percussion or impact fuse is ordinarily combined with the time fuse. In the typical fuse sleeve I slips over J at the time of firing, exposing pin K. Upon striking, I and J move forward and pin K strikes primer L, which ignites magazine F by way of D and C and explodes the shrapnel. For percussion the fuse is left set as for transportation.

The range of the 3-inch type of shrapnel shell is about 6,500 yards, and the muzzle velocity of the quick-firing field gun ranges from 1,700 to 1,930 feet per second. The rapidity of fire ranges from 15 to 25 times a minute, and the average weight of the projectile is 18 pounds. The duration of flight ranges from 21 to 25 seconds, and when the bullets (about 350 per shell) are blown out of the shell by the bursting charge they are given an increased velocity of from 250 to 300 feet per second. The velocity of the shrapnel at 6,500 yards is about 724 feet per second. In all cases the lead bullets are about one-half inch in diameter, weigh approximately 167 grains, and are kept from moving in the shell by a resin or other smoke-producing matrix. The matrix and bursting charge of black powder are also used as a tracer. It is important that the explosion of the shrapnel be plainly seen, so that observers can direct the accuracy of the gunfire. With shrapnel for field guns at long range, certain conditions of the atmosphere make it difficult to see when the shrapnel actually bursts, and various mixtures are used to overcome this difficulty. In some instances fine-grain black powder is forced in with the bullets. In German shrapnel a mixture of red amorphous phosphorus and fine-grain powder is used and produces a dense cloud of white smoke.

Shrapnel wounds are characterized usually by considerable contusion and destruction of deep tissue, as a result of the "mushrooming effect" of the soft unjacketed lead bullet, especially when compact bone is struck. They are always infected wounds, and it is not unusual to find pieces of clothing and distorted bullets in these wounds (figs. 30–33).

On account of the barbed-wire entanglements and other obstructions used in the present trench warfare, it has been found necessary by both sides to employ an increasingly large number of high-explosive shells, which are usually used in siege operations to clear the way in advance of assaulting troops. While they are used exclusively in the larger but stationary guns, they are also manufactured on a very large scale for the mobile light field pieces ("75," "77," and 3-inch). These shells are, as a rule, fused to burst on impact only. The firing pin of the detonating fuse is armed practically as described for the percussion firing pin of the combination fuse. Upon impact the firing pin strikes a primer which detonates a small quantity of fulminate of mercury or other detonant contained in the forward end of the fuse. This in turn detonates the high-explosive bursting charge and causes fragmentation of the thick shell. In figure 38, A is the metal part of the shell, B is the high explosive, C the detonating fuse, D the copper rotating band, and E a copper base cover. While used in light guns primarily to attack small field works and such objects as can be appreciably injured by a small charge of explosive, they give rise to an exceedingly destructive wound when the large fragments incidentally strike the soldier.

As already indicated, shell and shrapnel wounds are practically always infected, on account, not only of the large gaping wound, but also on account of the pieces of clothing and dirt driven into the tissues by the missile (figs. 34–41).

The high-explosive shell, particularly that of the lighter field pieces, gives rise to small as well as large fragments, and there are usually multiple wounds from the same shell.

The necessity of carrying both high-explosive shell and shrapnel, and the impossibility of predicting the proper proportion, has led to attempts, on both sides, to develop a compromise projectile which would perform the function of both. This has resulted in the high-explosive shrapnel (fig. 39), a shell which as yet is in its infancy of development, but which bids fair to replace both the former types of projectiles. If it is desired to use the shell as shrapnel, the time fuse is set and, upon explosion in the air, the head and balls are driven out to the front. The head is larger than the common shrapnel, but the combination fuse is on the same principle. The construction of the rear portion of the projectile is the same as that of the common shrapnel except that the matrix surrounding the balls is a substance, such as trinitrotoluol, which will merely burn when ignited by black powder, but which will act as a high explosive if a detonating fuse is exploded in contact with it. When it is desired to secure the effect of a high-explosive shell the fuse is not set, and upon impact the head detonates as explained above.

Figure 39, in addition to illustrating the principles of the high-explosive shrapnel, shows the modifications made in one type to render it more effective against air craft. At B is a partial annular ring of inflammable material, resembling the time ring of a combination fuse. It is ignited by flame from passage A at the time the base charge is exploded. As the head, C, continues its flight, a trail of smoke is left by B, and after a certain time B burns around to D and ignites the detonator E, which latter detonates the head. A quantity of smoke-producing material at F is intended to increase the visibility of the burst. As the two explosions are separated by a considerable distance, the chance of fragments hitting an object in the air is increased, and the flame from B would explode a balloon under certain circumstances (fig. 43).

When the war began ammunition was being issued to the "75" in the proportion of one-half shrapnel and one-half high-explosive shell. Recently, at the unanimous request of French artillery officers, the manufacture of shrapnel was discontinued. There is plenty of evidence to show that the French shrapnel was highly effective, but the artillery officers considered the high-explosive shell much better, both on account of effectively sweeping a larger area and on account of the fact that in the vicinity of the explosion air vibration alone is sufficient to cause instant death. This fact has been proven by the examination of a great number of bodies, found on the scene of the explosion of these shells, dead without the slightest indication of a wound. French officers have stated that they have seen German soldiers hurled 10 meters into the air by the explosions of these shells. The "75" high-explosive shell explodes almost immediately upon leaving the ground, there being just enough delayed action in the fuse to cause it to explode between 5 and 7 feet above the ground.

The death from these shells, without any apparent wounds, has remained a mystery. An officer at the front sent to M. Arnoux, a French engineer, a pocket aneroid barometer which had been damaged by the explosion of a big shell three yards away from it. M. Arnoux found that one of the levers by which the oscillations of the mercury were transmitted to the pointer had been forced under the other instead of remaining on the same plane. He replaced the levers in position and put the barometer in an air-tight vessel from which latter he pumped out the air. When the pressure had thus been reduced from 760 to 410 millimeters (the figure recorded on the top of Mont Blanc at an altitude of 15,782 feet) the levers assumed the position in which he found them. It was thus shown that the explosion had caused a sudden atmospheric depression to the extent of about 350 millimeters of the mercury tube, corresponding to a dynamic pressure of about 10 tons to the square yard. The men exposed to this violent change met with conditions similar to work-

men who leave compressed air chambers without taking the proper precautions, the effect being to liberate nitrogen suspended in the blood and to transform it into bubbles of gas. These bubbles are driven by the action of the heart into the capillary vessels, stopping the circulation of the blood in the vital centers and causing instant death. But it would appear that this explanation does not take into consideration the primary air compression by which men, as stated above, are sometimes hurled into the air as a result of the explosion *per se*. Therefore, it may not seem unreasonable to assume that these deaths without apparent wounds may be due to the blow the body receives from the primary violent air-impact, delivered as a blow over one side of the body and especially over heart and readily compressed abdomen, thus causing reflex actions that register themselves with fatal effect.

The "75" high-explosive shell is as follows:

Weight of projectile	pounds	11.7
Weight of bursting charge	ounces	29.0
Weight of propelling charge	do	22.5
Initial velocity (feet per second)		1,920

Comparing the bursting charge contained in the French shell (29 ounces) with the bursting charge of the German shell ("77"), which is only 5.5 ounces, the comparison seems ridiculous, but this difference is explained by the fact that the Germans are developing a high-explosive shrapnel, to replace both their present shell and shrapnel, which contains a considerable amount of high explosive incorporated in the matrix of the shell.

The subject of light field artillery can not be dismissed without referring to the marked enthusiasm and confidence that both French officers and men exhibit in the "75" (fig. 46). The unbounded faith they seem to have in this weapon is truly remarkable. Whether this is born of a goodly share of inherent patriotism or whether it represents an expression of the real merits of the gun, only time and history will show. The fact remains, however, that with such implicit confidence in the superiority of their "75" over all others, it would seem to be a considerable factor in promoting and sustaining an excellent morale among all classes of French soldiers. This factor alone is of great value, regardless of any proved superiority of the gun. Not until statistics on both sides have been compiled and edited can a trustworthy opinion be formed.

ASPHYXIATING GAS.

Chlorin or bromin gas, compressed to liquid form and liberated from large metal tanks when the wind is blowing toward an opposing trench, has caused very distressing deaths when inhaled in concen-

trated form. Being heavy gases, they hug the ground, moving to leeward, and sink into the trenches. The first effect is to cause the eyes to water, and this is quickly followed by a violent irritation of the bronchial tract. If troops are unprotected, and remain in the trenches, they rapidly develop a capillary bronchitis, with a hypersecretion of thin watery mucus, which fills up the air spaces of the lungs and practically causes death from drowning. Those receiving concentrated doses have died in from one to three hours, sometimes from edema of the glottis, but principally from exhaustion of the heart in trying to pump the blood through the engorged capillaries surrounding the bronchioles and ultimate air spaces of the lungs. This suffocating process sometimes lasts from one to three days, the younger men with stronger hearts holding out longer than the older.

The mortality from this form of suffocation depends on the degree of concentration of the gas inhaled and the age of the patient. Many cases have been mild on account of the capricious action of the wind in distributing the gas along the trenches, some parts of the line receiving it in more concentrated form than others. This results in all stages of an asphyxiating bronchitis, from the grave cases which are cyanosed and gasping for breath to those suffering from a mild form of irritation of the bronchioles. On this account some recover quickly and others, lingering for a longer period, slowly regain the normal, not infrequently exhibiting more or less marked evidence of bronchiectasis. The post-mortem examinations of the lungs show them to be about four times their normal weight, with an enormous dilatation of the air spaces, which latter are filled with a thin, watery, and sometimes blood-streaked mucus.

As regards treatment, those in the open air seem to suffer less. Oxygen gas, administered slowly, unquestionably gives relief. Atropin, hypodermatically, is used for the overdistended right heart, while the lateral-prone position of the patient favors drainage of the lung fluid.

By far the most important treatment is, of course, the prophylactic use of some form of combined helmet and respirator, which is intended not only to render the gas innocuous, but also to protect the eyes. When the gas was first used it came as a surprise, and there were many more victims than at present. There are a number of different types of protecting masks in use, all having for their object the neutralization of the gas when inhaled through the mask or helmet. Experience has taught that to be effective the protecting apparatus must either be in the form of a helmet entirely covering the head and tucked in at the neck, or in the form of a mask fitted snugly around the face under the chin and over the front part of the

cap above the visor, by means of strong elastic and tape (fig. 47). The mask or helmet should be made of some impermeable material, such as mackintosh, with a piece of transparent celluloid, about 8 inches long by 3 inches wide, sewn into a corresponding elongated oval opening cut in the mask opposite the eyes. That part of the mask in front of the nose and mouth is punctured by about 25 small round openings arranged in the form of a square. Behind these openings, inside the mask, a slightly larger square piece of cloth, also punctured with holes, is sewn so as to form a pocket for a little pad, impregnated with chemicals, which is slipped into the pocket just before the mask is to be used.

The pad in this form of protector is about 4 inches long by 3 inches wide and contains an equal quantity of hyposulphite and bicarbonate of sodium distributed equally throughout the pad by a few loose stitches holding the sides of the pad together. When the protector is to be used, about 1 ounce of water is poured on the pad from a small bottle, the latter kept in the soldier's coat pocket for that purpose, and the pad is then slipped into the pocket of the mask just before the latter is adjusted.

The first forms of masks consisted simply of gauze or oakum saturated with the chemicals and secured around the mouth and nose. This did not protect the eyes, which quickly became irritated, so that it was impossible to keep them open for long when the gas was concentrated. This, of course, prevented the soldier from fighting in the presence of gas. It was also thought that it complicated matters by having the chemicals in solution beforehand, whereas in the form of mask described above it was only necessary to pour water on the pad before using. Several of these pads are furnished with each mask, to be kept in a tin box in the pocket along with the small vial of water. The mask form of protector is thought to be much more practicable, in that it is not as disagreeably hot as the helmet form and can easily be secured above the visor when not in use, thereby making it more easily accessible at all times. Masks containing a pad saturated with limewater or turpentine have also been used.

Not infrequently the gas may be seen for some distance as a thin greenish-yellow cloud, and it is ofttimes possible to detect the odor for an appreciable time before it becomes concentrated, thereby giving sufficient warning to allow the masks to be adjusted in time to meet the oncoming gas.

Flame projectors (*flamenwerfer*) are used by the Germans for throwing burning liquid. They are very much like the ordinary portable fire extinguisher in construction, throwing a liquid which at once catches fire spontaneously and has an effective range of 30 meters. The burns caused by this method are of the deep, sloughing

variety, exposing tendons and bones, and are treated with wet dressings until healthy granulations appear. These flame projectors are mainly employed in street and house-to-house fighting, although their use in the trenches has been reported a number of times.

Hand grenades (bombs) and shells have recently been employed at short range to produce an irritating and asphyxiating gas on bursting. Although intended to render portions of the trenches untenable, reports from the front indicate that their action is very variable and much influenced by the presence of wind. The necessarily small quantity of gas that is evolved at the time of bursting has a very restricted local effect.

PART II.

THE ORGANIZATION FOR THE TRANSPORTATION AND CARE OF THE SICK AND WOUNDED.

The evacuation and care of the sick and wounded has always constituted a problem of the gravest import in every campaign of history. Progress in this direction has not by any means kept pace with the advances made in perfecting the means for destroying human life and property. The history of every war has shown that the implacable working formula, so often quoted, "Ammunition first, food second, and wounded third," has not changed, nor has it received the consideration, in regard to alleviating the condition of the last factor of this formula, that its importance warrants.

The task of evacuating the wounded is, even at its best, a complicated one, and there is no other class of military work which undergoes such unexpected and startling variations. For this reason the military surgeon must not only be skillful professionally, but he must be a man of above the average courage and resourcefulness. The medical department, at the front or rear, in military operations of any magnitude is always taxed to the utmost to meet the demands made upon it. This is largely due not only to lack of numbers in the corps adequately to cope with the enormous number of wounded which may suddenly need attention, but the rapid expansion of the medical corps in war time, both personnel and matériel, is not conducive to smooth running and well-regulated machinery. Hence it is at the outbreak of war the medical department is never at its best, but as time goes on its various units become better organized and can render much more valuable and efficient service.

As is well known, the three different phases in the movements of a division or an army are that it may advance, it may retreat, or it may remain stationary. Any one of these operations is capable of all sorts of variations along the front, and may suddenly create situations of the greatest difficulty for any one or many of the sanitary or medical department units. If the army advances, the wounded become each moment farther removed from the enemy, and there is no serious difficulty in following up and evacuating the wounded to the rear, provided the transportation facilities are adequate. This phase of the allied operations occurred after the decisive Battle of

the Marne, which resulted in the German retreat. When an army retreats, however, the difficulties multiply. The enemy advances with more or less rapidity, and the first-aid stations, temporary hospitals, field and clearing hospitals must be evacuated without delay. Frequently the patients can be removed to the rear, but too often the evacuation can not be effected rapidly enough, and the wounded must be left where they are in charge of one of the surgeons who remains behind. The equipment thus becomes scattered or lost and has to be renewed, this latter taking time and a further expenditure of nerve-racking energy. This was the condition of affairs following the allied retreat from the north after the Battle of Charleroi. When an army remains practically stationary, as in the case of the present trench warfare, the situation is favorable for efficient work on the part of the medical department, in that the latter has time to perfect and maintain its organization.

Figure 52 represents the actual lines of communication of one of the French armies at the front, showing in detail the dispositions with reference to maintenance of supplies of all kinds, and of the hospital facilities in the immediate rear. The roads and railway systems in the "zone of the armies" are under the absolute control of the commander-in-chief. The engines, cars, and other means of conveyance are entirely separate from those of the "zone of the interior" and are manned by soldiers. While the State has control of all the railroads in time of war, there is a sharp distinction drawn between the authority of the two zones.

In the "zone of the interior" the railways are operated by the regular employees of the particular railroad, all being under the minister of war who controls this means of communication through the director of the railroad. This zone has to do with the concentration and transportation not only of men to and from the "zone of the armies," but also supplies of all kinds needed at the front. The field training and concentration camps are located at variable and strategic points in the "zone of the interior," while the regular garrisons and posts are constantly receiving recruits for training and then forwarding them at intervals to the field camps where the training is completed.

Le service sanitaire, or as it is also called, the *Service de santé*, is the French organization, under the minister of war, which has charge and direct control of everything pertaining to the sick and wounded from the time they leave the trench or firing line, on through the various intermediary stages, and until they are discharged from treatment at a base or auxiliary hospital. There are two distinct branches of this service, one being called the "service of the advance," which works exclusively in the "zone of the armies,"

and the other being called the "service of the rear," which latter takes up the entire medical and surgical work of the "zone of the interior."

The medical department, or sanitary service as it is known in the French Army, is responsible for carrying out the following in the

FIG. 52.—For description see text.

field: (1) The anticipation, preparation, and execution of all necessary hygienic and prophylactic measures; (2) medical attendance upon troops on the march or at field stations; (3) first-aid during combat, collecting, transportation, and evacuation of the wounded whatever their nationality; (4) the organization of immediate hos

Fig. 53.—Gite d'etapes along a railroad behind the British lines in the zone of the interior.
(See page 33.)

Fig. 54.—Infirmerie de gare along a railroad behind the British lines in the zone of the interior.
(See page 33.)

Fig. 55.—Depôt d'éclopés operated by the Red Cross in the zone of the interior. (See page 33.)

Fig. 56.—French hospital train. (See page 39.)

Fig. 57.—Interior of hospital train operating in zone of the interior with a capacity of 12 patients to the car. (See page 39.)

Fig. 58.—Light ambulance for carrying three stretchers. (See page 41.)

Fig. 59.—Four-stretcher car for base work. (See page 41.)

Fig. 65.—Other experimental types of motor ambulance used in base hospital work.

Fig. 66.—Two-wheeled horse cart used to transport the wounded in the early days of the war.
(See page 43.)

pital or ambulance accommodation for the sick and wounded; (5) replacing the personnel and resupplying the matériel for the regimental and other sanitary formations at the front. To each army headquarters is attached a medical personnel, with reserve matériel, in keeping with the importance of the command.

The term "ambulance" is used by the French and other continental nations as a general term for a hospital, although the latter term is used usually in the sense of a sanitarium. Other terms are employed to indicate a specialization of some particular form of sanitary work. Thus *gite d'étapes* (fig. 53), of which there are a conspicuous number along all the roads and railways leading to the rear, means an eating and resting place for the sick and wounded; *infirmerie de gare* (fig. 54) is a railroad station equipped to supply the general needs of the wounded en route; *depôt d'éclopés* (fig. 55) indicates a place for treating the lame and slightly sick or wounded who are to return to the front in a short time; and *ambulance de campagne* means usually a field hospital of the mobile type, although it may indicate a fixed hospital in the field. The French also have a term "*auxiliaire*" doctor, which signifies one who has not completed his medical studies or training but who performs certain duties under the eye of a commissioned surgeon.

The regimental personnel and matériel of the sanitary units with troops in the field are as follows: Infantry—1 surgeon and 1 assistant surgeon or *auxiliaire;* 4 trained hospital corpsmen; I two-wheeled cart, 8 stretchers, and knapsacks containing dressings and equipment for treating 650 wounded. Engineers—the same as infantry per regiment, although they usually work in the field as a company, having 1 assistant surgeon and 1 hospital corpsman, with dressings and equipment for treating 70 wounded. Cavalry—1 surgeon, 1 assistant surgeon, 1 *auxiliaire*, and 4 hospital corpsmen; 2 light two-wheeled horse carts, 4 stretchers, and knapsacks containing material for treating 200 wounded. Artillery—in groups of three batteries, each group having 1 surgeon, 1 assistant surgeon, and 4 hospital corpsmen; 1 light two-wheeled horse cart with dressings and equipment for 200 wounded. In addition to this each soldier carries with him a first-aid package with instruction how to apply it to the treatment of limited wounds.

In addition to the above personnel and matériel, there are assigned the following units to formations in the field: Regimental ambulance (of about a hundred beds), which is usually of a mobile character, having 4 surgeons, 1 pharmacist, 2 administrative officers (commissary and statistical), and 30 hospital corpsmen; a variable number of mules with double saddles for transporting 2 wounded, and 6 four-wheeled ambulance wagons. Divisional ambulance (of from two to

three hundred beds) which is of a stationary character, having 6 surgeons, 1 pharmacist, 2 administrative officers, and 140 hospital corpsmen; 17 mules with double saddles, and 21 light four-wheeled horse carts. Army corps ambulance (500 or more beds), having 9 surgeons, 1 pharmacist, 2 administrative officers, 4 chaplains, and 210 hospital corpsmen; 22 mules with double saddles and 27 light four-wheeled horse carts. Both the divisional and army corps ambulances are hospitals of the evacuating variety, conveniently situated near railroads or canals for this purpose; although they also accumulate those cases which are too serious for further transportation. The so-called clearing hospital is a variety of an evacuation hospital, situated directly on the railroad and intended for the collection of the sick and wounded who are to be periodically evacuated to the interior by hospital or sanitary trains. There are also located at certain points, usually in a convenient town or village, groups of reserve surgeons and hospital corpsmen, and reserve supplies, wagons, horses, mules, and automobiles intended to replace quickly any deficiencies at the front.

The railway systems operating in the direction of the front and having in view the commercial interests of the various towns and cities, have modified and reconstructed their various lines and branches to meet the demands of the war situation. The nearer the approach to the fighting zone the more the railroad accommodates itself to the particular demands of that part of the line, until the special network of strategic tracks in the "zone of the armies" forms a special system of its own. Figure 67 represents the organization of the French railroads with reference to handling the wounded from the "zone of the armies" to various points in the "zone of the interior," where they are further distributed to the base hospitals. Although the armies form a continuous battle front, each has its organization for the transportation of its own wounded. While there is necessarily a certain intercommunication between two armies operating next to each other, their equipment for handling their wounded is separate, as is the case in handling their supplies of all kinds. In case one army is engaged more continuously, or has more wounded to transport than another army, the latter would furnish the necessary extra equipment and rolling stock for this increase in the local demand on the "service of the advance." The medical department operating in the "zone of the interior" (called the "service of the rear") would make any necessary temporary changes to conform to the work of the "service of the advance."

The "refuge for the wounded," of which there are a large number all along the line, is a protected spot, located in recesses of the ground immediately behind the first line of trenches. The wounded either

walk or crawl to these spots, or are carried by their comrades; and it is here that the "*auxiliaire*" doctor is stationed, with several hospital corpsmen and supplies, to render urgent assistance and arrange the wounded for transfer at opportune moments to the first-aid stations. It is also at this spot, and in the trenches, that the

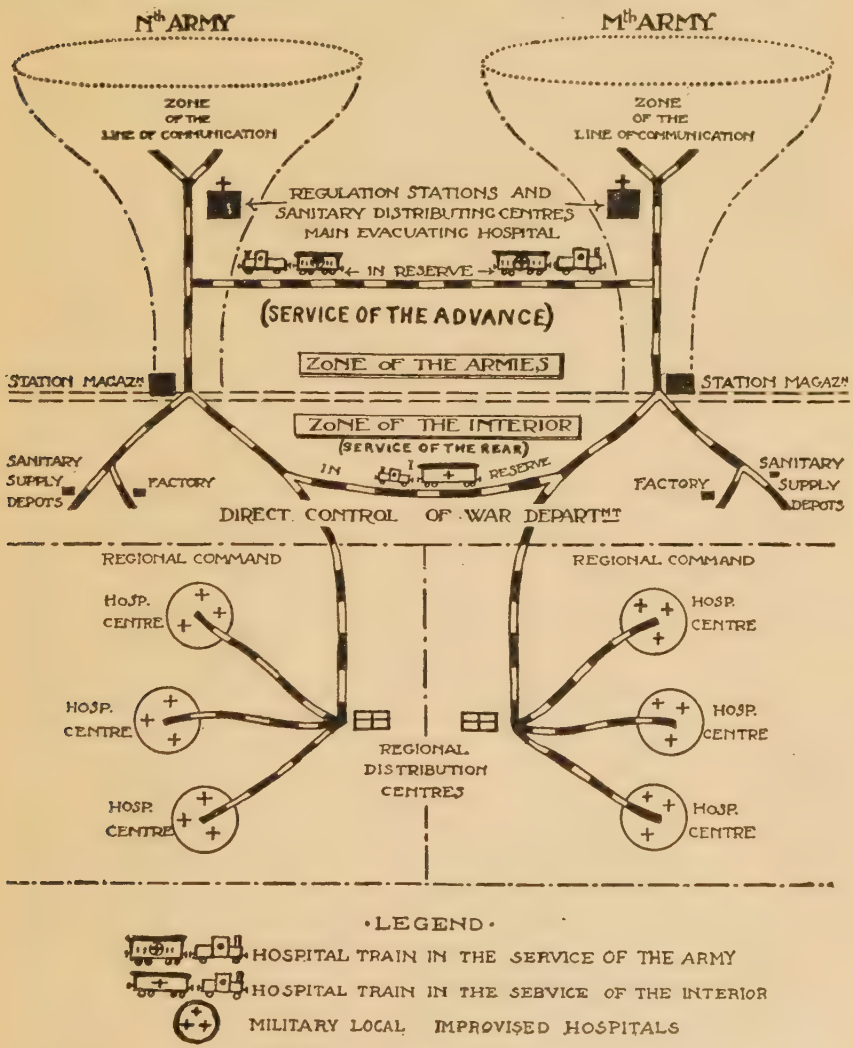

FIG. 67.—For description see text.

wounded usually use the first-aid package with or without assistance. The stretcher bearers who carry the wounded at times from the trenches, but principally from the "refuge spots" to the first-aid stations, are 17 men detailed from each battalion and, in addition to these, there are 38 bandsmen from each active regiment who also act as stretcher bearers.

The first-aid station, or *poste de secours*, is located in a sheltered spot or in the cellar of a house at a variable distance behind the regimental reserves, usually from five hundred to a thousand yards, and is provided with water, large and small dressings, and surgical equipment for the rapid treatment of wounds. It is here that the antitetanic serum is injected and the wounded tagged and grouped

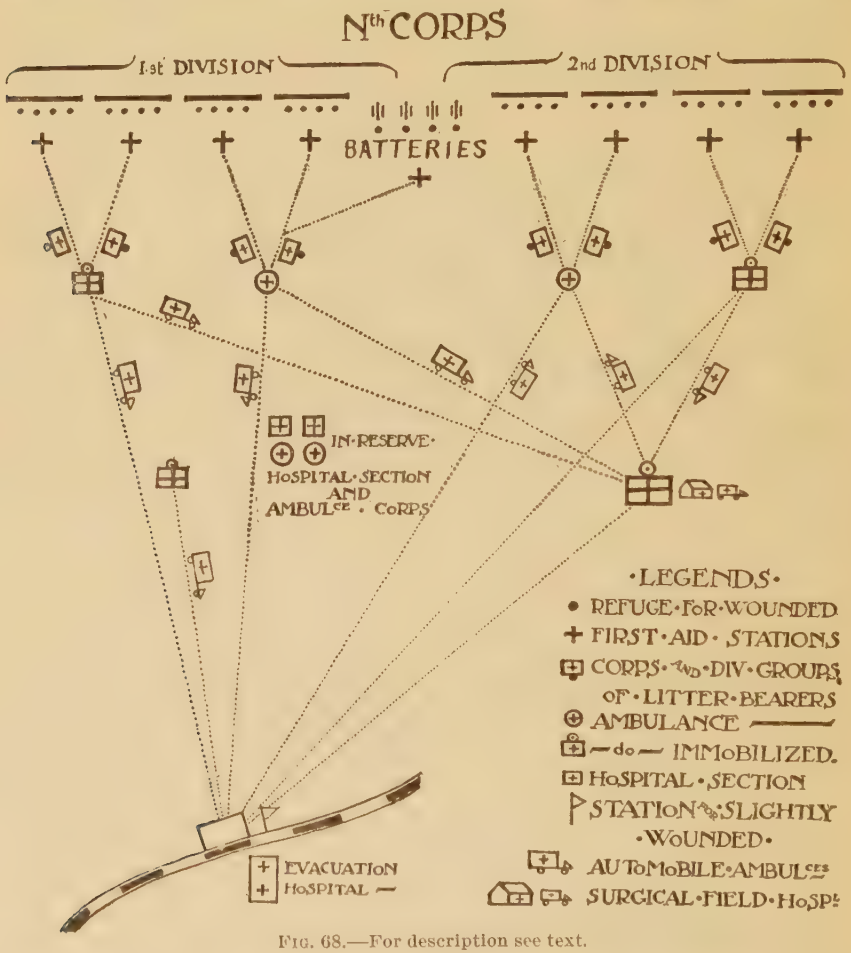

FIG. 68.—For description see text.

for transfer to one or the other of the various ambulances in the field.

Figure 68 shows the disposition of the sanitary units and formations for one army corps. While it represents the actual organization of the medical department at the front, each unit or formation takes advantage of any form of local protection, such as behind a hill or inside of a building. For this reason each sanitary group or station may not be the same distance behind the lines as a corresponding

group and there may be no regular disposition of the first-aid stations, the latter being placed at convenient points on intersecting roads or in a small village, where reserves of personnel and matériel are also located. The two-wheeled carts are used principally to pick up the wounded in a rapid evacuation from the "refuge spots," and the light four-wheeled horse carts carry the wounded from the first-aid stations to the nearest field hospitals or ambulances.

While the sanitary organization of each regiment has its mules and two-wheeled and four-wheeled horse carts for carrying their wounded, there are a large number of specially constructed automobiles operating at the front for the same purpose. These automobiles usually operate in groups of 10, under the control of a director of autocars, and these latter transport the wounded rapidly from either first-aid stations to ambulances or from one ambulance to another. The personnel of these auto units are volunteer civilians from America, France, and England, who undertake this character of work for the period of the war. The number of these autocars accredited to a division or army corps is variable, and their presence in the field is usually due to the generosity of philanthropic individuals or societies. Each group of about 10 cars has a pilot car and a repair car, which latter carries two mechanics, extra tires, gasoline, and spare parts of all kinds. One or more groups of these auto-units are assigned by headquarters to the different ambulances in the field, which latter direct their movements.

It ofttimes happens that the automobile can not approach closely the first-aid stations without attracting the fire of the enemy, and it is then that the two-wheeled carts, pushed by one or two men, are very useful in carrying the wounded to the automobiles. All of the sanitary units above mentioned in the field advance with the columns of which they form a part. In case of a minor or local advance anywhere along the line, the corresponding sanitary units in the immediate front push forward with the advance guard.

All hospitals in the field are established, under the direction of the surgeon in command, in the rear of the divisional reserves. They occupy a sheltered position, provided with water, and may consist of a group of tents or a combination of tents and houses locally requisitioned. Ofttimes schoolhouses, churches, hotels, and other large buildings are used in establishing a field ambulance. In general, except under circumstances to be noted later on, no operations of a complicated character are performed in any of the field ambulances. Urgent surgery, such as for hemorrhage, perforating abdominal or head wounds, absolutely necessary amputations, the redressing of wounds and the application of suitable splints, is the character of work in these field hospitals or ambulances. In addition to this the sick and wounded are classified for further disposi-

tion, the necessary supporting treatment is instituted, and any other special means are used to render the patients more comfortable and in a suitable condition for transportation.

Figure 69 shows in detail the actual organization of the medical department or sanitary service, immediately behind the trenches of a certain part of the French line where the conformation of the ground,

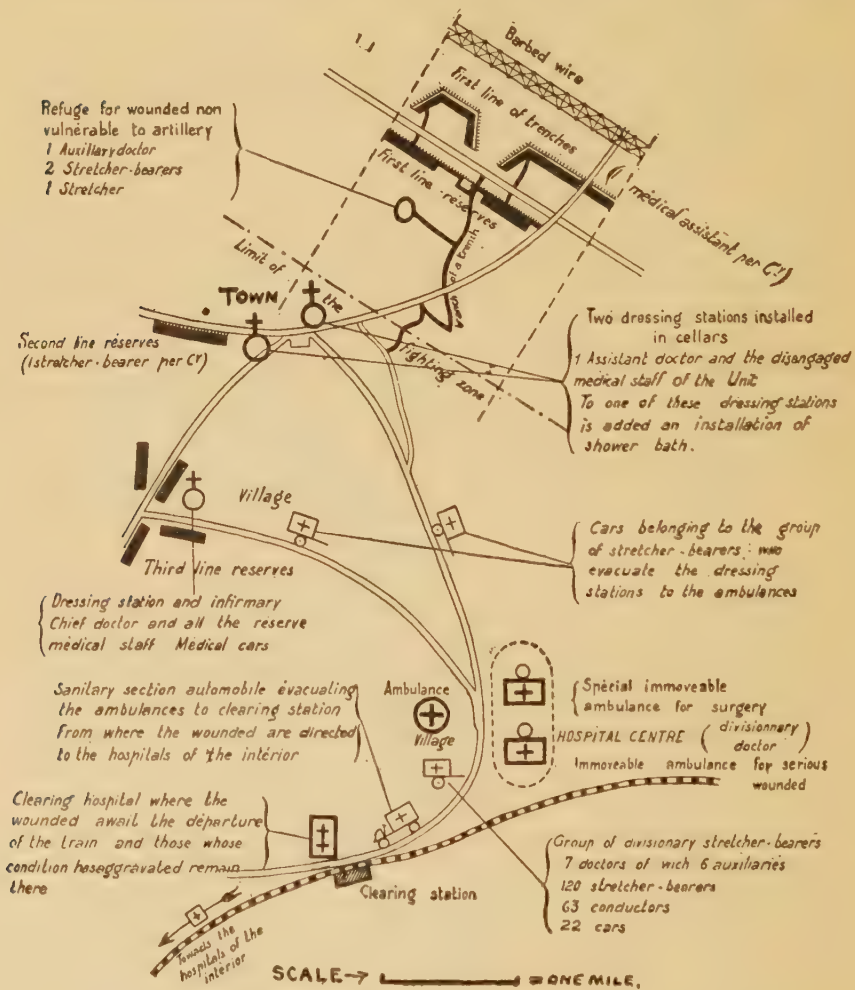
Barbed wire
first line of trenches
first line réserves
Refuge for wounded non vulnérable to artillery
1 Auxiliary doctor
2 Stretcher-bearers
1 Stretcher
Limit of
TOWN
the
Second line réserves (1 stretcher-bearer per Cr)
fighting zone
Two dressing stations installed in cellars
1 Assistant doctor and the disengaged medical staff of the Unit
To one of these dressing stations is added an installation of shower bath.
Village
Third line reserves
Cars belonging to the group of stretcher-bearers who evacuate the dressing stations to the ambulances
Dressing station and infirmary
Chief doctor and all the reserve medical staff Medical cars
Sanitary section automobile évacuating the ambulances to clearing station
From where the wounded are directed to the hospitals of the interior
Ambulance
Village
Special immoveable ambulance for surgery
HOSPITAL CENTRE
divisionnary doctor
Immoveable ambulance for serious wounded
Clearing hospital where the wounded await the departure of the train and those whose condition has aggravated remain there
Clearing station
Group of divisionary stretcher-bearers
7 doctors of wich 6 auxiliaries
120 stretcher-bearers
63 conductors
22 cars
towards the hospitals of the interior
SCALE
ONE MILE.

FIG. 69.—For description see text.

the particular character of the fighting, and the strategic necessities have called for these special dispositions.

In classifying the wounded, after their reception at a first-aid station or a field ambulance, those whose wounds are so slight as to permit of their returning to the front within a short period are segregated; those whose wounds permit of their walking are formed

into detachments and directed to the rear; and those incapable of walking are transported by wagons or automobiles to the appropriate sanitary formations in the rear (surgical field ambulances, divisional evacuation or clearing ambulances, or any one of the several special sanitary units already described).

The French estimate that 3 per cent losses per day can be counted on for an organization on the march or quartered. Oftttimes the sickness is only temporary and the men rejoin the ranks. With troops under heavy fire, 50 per cent of losses are estimated for a small military formation (company or battalion); 20 per cent for a large unit (division); and 15 per cent for an army corps.

That portion of the *Service de santé* which operates in the "zone of the interior" is called, as already indicated, the "service of the rear," which has for its object the continuous evacuation of the sick and wounded, their distribution to appropriate hospitals in the interior, and also supplying every need of the "service of the advance." While a few of the base hospitals of a special character are so favorably situated as to have the wounded transferred to them in automobiles from the "zone of the armies," yet the vast majority of the wounded which reach the large base hospitals are conveyed by sanitary or hospital trains.

Figure 70 shows in detail the organization of the medical department in the "zone of the interior" (service of the rear) behind one of the French armies, with special reference to the disposition of hospital units and the operation of the railway system in the immediate front of the "zone of the interior." As regards the railway facilities for handling the wounded, there are three kinds of sanitary or hospital trains—the permanent, the improvised, and the ordinary passenger train fitted up specially for the purpose (figs. 56 and 57). The permanent hospital cars are comparatively very few in number and are not often used, for the probable reason that they contemplate carrying but few wounded. They are in the nature of private cars with a few well-equipped compartments. Occasionally one or more of these cars will be attached to an ordinary passenger train, in which case they are in use for a special reason, such as the transfer of seriously wounded officers. The improvised train is composed of baggage or cattle cars, with the stretchers arranged in three tiers and suspended from stanchions by means of heavy spiral springs, the latter known as Brechot or Améline suspension apparatus. These cars carry 18 wounded, with a hospital corpsman to each car, and are heated in winter by small stoves in the middle of the car. Trains composed of these cars are only used at the present time for short trips in the "zone of the armies" and when the regular passenger cars are not available. One surgeon accompanies each train.

At the beginning of the war the patients could only be fed at certain stations along the line. This necessitated long stops and greatly delayed the progress of the train. Noncommunicating cars were also used at first which only permitted the surgeon to inspect the cases at stations, the latter usually being at intervals of from four

FIG. 70.—For description see text.

to six hours apart. This service has been greatly improved by the intercommunicating cars and by the addition of a restaurant car. This arrangement allows the surgeon to supervise the treatment of serious cases throughout the duration of the trip and to determine the gravity of the wounds before reaching the *gare d'évacuation* or distributing station.

The head station of the hospital train is called the *gare d'origine d'étapes*, which operates in connection with a large clearing or evacuation hospital. Small infirmaries are located in each railway station along the line, to which patients unable to stand further transportation may be removed. The station of final arrival is called the *gare d'évacuation*, from which the patients are distributed to the local or regional base hospitals by means of motor ambulances. There are two such *dépôts* of distribution in Paris, the "*gare d'Aubervillers*" and the "*gare de la Chapelle St. Denis*." These latter *dépôts* are very large structures, having from 15 to 20 small and completely inclosed sheds located on the floor of the building, and separated from each other by about 30 feet. These smaller sheds, each of which is heated in winter by a stove, accommodate 20 stretchers supported on small wooden horses.

As soon as the train arrives it is met by the surgeons and attendants attached to the *dépôt*, and the sick and wounded, which have already been classified by the train surgeon, are rapidly transferred to the small inclosed sheds. The contagious and other medical cases have special sheds, which are separate and distinct from the surgical sheds. There is also a well-equipped operating shed and dressing room, which is used when necessary for urgent cases. There is also a large kitchen, which prepares in advance appropriate food for distribution to each of the patients before they are sent to the various base hospitals.

The surgeon in charge of the *dépôt* has a corps of professional and clerical assistants; each case is carefully examined and recorded before being transferred, and a receipt is taken for each patient turned over to the ambulances. A daily report is made to the office of the *dépôt* surgeon which indicates the number of vacant beds in all the hospitals of the city, and when a hospital train is expected a call is sent out from the *dépôt* to various hospitals for the necessary motor ambulances. In this manner the sick and wounded reach the hospitals best suited to treat them. The motor ambulances which respond to the call may not be sent back with patients to the hospitals from whence they came, but are subject to the direction of the *dépôt* surgeon. In addition to *dépôt* orderlies there are a large and variable number of volunteer Red Cross nurses, who add greatly to the comfort and efficiency of the *dépôt* service.

As already indicated, there are quite a large number of motor ambulances operating in groups in the "zone of the armies." Various experiments with different types of motor cars for transporting the wounded were undertaken, after the Battle of the Marne and the German retreat, with the idea of perfecting a standard motor ambulance for field and base work (figs. 58–61). These experiments

crystallized the earlier conviction that the best type of motor ambulance for field work, and to a large extent for base work, was a light American-made car, which on account of its exceptional clearance from the ground, together with its reliable engine and other mechanical parts, made it an ideal car for work immediately behind the firing line. It has proved to be the only car which could get off the road into the mud, to allow a convoy to pass, and yet get back to the road without the aid of a towline. On account of its light body and springs it was demonstrated that, for efficient work in the field over rough roads, the car should not be loaded with more than three stretcher cases.

Ordinarily only two stretcher cases are transported in these cars, but an emergency stretcher is supplied so that it can be placed on a wooden frame and secured in the center of the car above the other two stretchers. When the third stretcher is not in use it can be strapped to the roof of the car along with its supporting frame. In some of the cars the emergency stretcher is suspended from the roof by means of canvas straps supporting the framework, and also secured by lateral extensions from each side to prevent swaying.

The necessity of keeping the wounded warm was early recognized. For this reason, in addition to the blankets around the patient, the car is completely covered by canvas stretched over the body framework and snugly fitted over every opening. A large hurricane lamp, suspended from the roof, has been found to give sufficient warmth for the French winter climate. Other and larger types of cars, made to carry four stretcher cases and six to eight sitting cases, are in use for base hospital work, but they are entirely too cumbersome for fieldwork. The light American car, with its low outline, can creep up very close to the firing line without attracting the fire of the enemy.

It was found out that the greatest comfort to the patient was secured by placing the stretchers on the floor of the car, or on rigid framework, and not suspended by spiral springs, which latter would allow for transverse and longitudinal movement unless elaborately secured. Several types of base-hospital motor ambulances are made to load from the side, carrying six stretcher cases and eight sitting cases. These cars are also very large and cumbersome, travel slowly, and can not be used except over smooth roads. The English motor ambulance is of the four-stretcher type, and both heavier and larger than the ones in general use by the French. The photographs of the English type of motor ambulance were taken at the time of the visit of Queen Alexandra and the Princess Royal to a base hospital (figs. 60 and 61).

The allied forces were unfortunate at the beginning of the war in having to deal with the complicated situation of retreat, and at a time

when the *Service de santé* was least able to meet it. As already indicated, the wounded had to be left in the field, so rapid was the advance of the enemy, and many hundreds of wounded were disposed of in abandoned churches and schoolhouses without assistance of any kind for days. The sanitary organizations had to undergo rapid expansions to meet the enormous demands made upon them, and in consequence there was at first confusion in every department of the work (fig. 66).

After the retreat had been checked and the decisive battle of the Marne had been fought, there were a hundred and twelve thousand wounded, many of whom were Germans, which had to be cared for and transported to hospitals. So great was the demand for ammunition and other supplies that the improvised hospital trains were shunted on to sidings in order to make way for troop and supply trains, and this condition of affairs delayed the progress of the wounded toward hospitals for days. Under these circumstances nothing could be done for these wounded other than to subsist them on supplies locally requisitioned from near-by towns and cities. The hospital trains were usually cattle cars which had been hastily prepared and ofttimes in a very insanitary condition, so that it was during this period that a large number of cases of tetanus developed. Wide-spreading infection was also the rule at this time, as the wounds had to be left for days unattended; so that when the wounded finally reached a hospital it was after a very long and harrowing journey, which gave every opportunity for the infection to spread, in addition to depleting the vitality of the patient.

At the beginning of the war there were practically no contagious or other medical cases, but they soon began to appear and continued in increasing numbers during the winter operations. This at first was a serious handicap in connection with the sanitary train service, as the contagious cases were ofttimes not segregated properly, but as the organization developed special cars were used for medical cases as distinct from strictly surgical cases, and at the same time disinfection of the cars with sulphur and formaldehyd gas was instituted.

A number of ingenious arrangements for transporting the wounded by motorcycle have been devised, but on account of their very restricted field of usefulness are very seldom employed, and it is doubtful if they have any real practical value. The photographs of these vehicles are included, however, to show them in contrast to the regular motor ambulances (figs. 63 and 64).

The necessarily complicated system of transporting the wounded by trains results in certain delays which are of vital importance to the seriously wounded. One of the lessons of this war, as far as the handling of the wounded is concerned, is that as much use as possible should be made of motor ambulances to transport the seriously

wounded from the firing line to the clearing or evacuating hospitals, and even back to the base hospitals. The hospital trains should be reserved for the medical cases and the less seriously wounded. Experience has amply shown that certain types of seriously wounded, notably the gas gangrene cases, could have been saved both in life and limb if their journey had been shortened by better transportation facilities.

Another method of transportation toward the more remote hospitals of the interior is by way of canal boats (fig. 62). These boats are fitted for the purpose of conveying the slightly wounded, contagious, and other medical cases, and consist of large barges which are towed by tugboats. It is one of the methods taken advantage of to relieve the railroad congestion whenever a suitable river is near enough to the evacuating hospitals to admit of making use of this form of transportation.

The so-called "Red Cross" dog is made use of at portions of the front in connection with locating the wounded (fig. 97). They are used successfully for this purpose in the Vosges, in the Argonne forest, and other wooded regions. These dogs become very proficient in locating the wounded, and as an indication that they have found one they are taught to bring back to the station some article of clothing belonging to the wounded man, such as a cap or handkerchief. Lately they have been trained to carry ropes to the wounded in front of the trenches which enables a wounded man to be pulled back into the trench by his comrades. These dogs are of the same breed as the so-called "police" dogs and are trained for both rescue and police work at a station just outside of Paris.

The French Red Cross, or *Croix Rouge*, is a society of considerable proportions even in times of peace, with ramifications throughout the Republic, and is organized along the lines of the same societies in other countries. It is supported by voluntary aid and subscriptions and since the outbreak of the war has enormously increased in size and usefulness. Indeed, it is not too much to say that the continuous efforts put forth by different branches of this society are largely responsible for the comfort of the soldiers in the field and also of the wounded in the many hospitals scattered throughout the country.

Besides a large number of subsidiary branches with special names, the principal divisions of the French Red Cross are as follows: (1) "*Société de secours aux blessés militaires*," (2) "*Union des femmes de France*," and (3) "*Union des dames françaises*." All of these divisions and branches are represented on the central Red Cross committee, which controls the activities of the entire society and is in close touch with the ministry of war through the head offices of the *Service de santé*.

These divisions of the Red Cross, through their many branches, undertake to accomplish whatever is suggested as necessary, according as circumstances arise, for the welfare of the soldiers in general and the wounded in particular; together with helping the wives and children of the soldiers at the front and in hospitals, and also the care of destitute refugees. The first division is particularly interested in supplying the nurses and orderlies, both male and female, for base and auxiliary hospitals, *dépôts*, and infirmaries. The nurses are of two kinds, the graduate or trained nurse and the *auxiliaire* nurse; the latter being a volunteer untrained nurse who works under the supervision of the graduate nurse. All of these nurses give their services for the period of the war and are supported, when circumstances indicate it, by Red Cross subscriptions, and to some extent by the State.

The second and third divisions are composed of women from all walks of life, and they are not only untiring in their efforts to secure the necessary money to carry on the general work of the Red Cross and the buying of supplies, but they are organized into a large number of groups for special work. Thus some are engaged in the vast number of Red Cross *ouvroirs*, or workrooms, scattered throughout the many cities of France. It is in these places that material is gathered and worked up into hospital and sanitary supplies of all kinds. Other groups are busy collecting special foodstuffs, tobacco, cigarettes, magazines, and many other necessary articles for the soldiers in the trenches and hospitals. It can be truly said that there is not a woman in France capable of helping who is not doing her utmost to carry on some feature of this splendid work. Their dignified resignation, their eager acceptance of every opportunity to aid, and their splendid capacity for intelligent work, challenges the admiration and respect of all who come in contact with them. These organizations, in addition to their many activities, have furnished and equipped a large number of motor ambulances since the war began. They have taken up the work at home where their fathers, husbands, and brothers have left off, and it is safe to say that the women of France to-day are as equally responsible for the salvation of the country as the men.

There are also a large number of *auxiliaire* hospitals conducted entirely by the Red Cross (figs. 71–73). These hospitals are adjuncts to the large base hospitals, and as a rule are intended for convalescing patients. Hotels, public buildings, and private residences have been converted into these auxiliary hospitals, and convalescing patients are cared for here until they have recovered or until some final disposition is made of each case.

On account of the large number of wounded who have lost the sight of both eyes, some 2,000 in all, and on account of the large number

who have lost one or both arms and legs, the French Government is establishing, through their admirable Red Cross, a system of vocational training in different parts of the country so that these cripples can learn some trade or occupation best suitable to their condition, which will enable them to support themselves in after life and not be a burden to themselves or the State.

The Japanese, Russian, and Italian Red Cross societies have also established hospitals in Paris. These are base hospitals, located close together on the Champs-Élysées in former hotels. The Japanese hospital is the largest and most active of these, having 150 beds and capable of accomplishing any class of work. The staff consists of 3 Japanese Army surgeons, 1 French surgeon, and 1 French dentist, together with 20 Japanese graduate nurses and 22 French *auxiliaire* nurses. It is a strictly surgical hospital, splendidly equipped throughout, and the work done here is a credit to Japan (fig. 73).

There are also quite a large number of small converted hospitals, scattered throughout Paris and the interior, which are maintained by private citizens of both France and the United States. In the latter instance the doctors are brought from America at the expense of the individual who is financing the hospital, and the staff usually consists of a well-known American surgeon and two or three young doctors who have had hospital training. This staff remains for three months and is then relieved by another group. All hospitals, of whatever character, that are authorized to receive the sick and wounded of the French Army or Navy are under the supervision of the *Service de santé* and have to comply with the rules of this service with reference to filling out various blank forms and keeping track of all patients. In this way the ministry of war keeps in close touch with all military patients, and requires of each hospital a 48-hour notice before a patient is discharged or transferred, so that they can direct whatever disposition of the patient has been decided upon.

The English have practically the same general system of caring for their wounded as the French. Bethune, a small city north of Arras, is an active hospital center for fieldwork, as it is only from 2 to 3 miles distant from the trenches. From this sector and other points along the thirty-odd miles of front held by the English, the sick and wounded that are able to travel are evacuated to Boulogne, Rouen, and Versailles, at which places the English have established large base hospitals. The hospital at Versailles is one of the largest and best situated, having a capacity of 1,200 beds, with a daily average of about 850 patients. It is a general hospital, occupying a large new hotel building, with every modern appointment, just outside the wonderful park built by Louis XIV. Besides the hotel building,

there are a large number of hospital tents scattered throughout the beautiful grounds for contagious and other medical cases. The general run of cases and the treatment, with minor differences, are the same as noted in the French hospitals.

The hospital center at Rouen has about the same general characteristics as Versailles. Boulogne is one of the large English bases in France. It is here that vast war supplies are received for the British troops. Besides the large English Red Cross hospital under the general charge of Sir George Makins, with Sir Almroth Wright as a consultant, there are two large ambulance ships, fitted up since the war, which sail periodically from this center and convey all the convalescent British wounded in France back to the convalescent base hospitals in England.

Val-de-Grâce is not only the largest hospital in France, but is of considerable historic interest. It was founded by Anne of Austria, wife of Louis XIII, in accordance with a vow, after the birth (1638) of her son, afterwards Louis XIV. Originally a Benedictine nunnery, it has been a military hospital since 1790, with a military medical school as an adjunct. The beautiful chapel erected by Anne of Austria, modeled after St. Peter's in Rome, and planned by the famous architect Mansard, is still one of the sights of Paris. With the exception of the chapel the buildings were all remodeled and enlarged by Napoleon. A large bronze statue of Baron Larrey, Napoleon's famous army surgeon, occupies a prominent position in the chapel court. Although an active military hospital since the time of the first Napoleon, with excellent service during the Franco-Prussian war, it can hardly be said to have received much governmental help, as regards upkeep and repairs, until the outbreak of the present war.

The hospital buildings are divided into a number of different services, each apparently distinct from the others, with a general capacity of 2,200 beds. There are medical, surgical, eye and ear, nose and throat, contagious, genito-urinary, and military prisoners services. The surgical service has a large and growing surgical-dental department, which is especially active on account of the large number of jaw cases resulting from the present trench warfare. Not a few of these cases are eventually transferred from this and other hospitals to the excellent surgical-dental department of the American ambulance hospital at Neuilly for further treatment. A large number of military insane patients pass through Val-de-Grâce, apparently for record only, and are then transferred to various asylums in the interior. It was said that by far the greater number were young soldiers with an alcoholic history.

The French Government is very reticent as regards statistics of all kinds, and no reliable percentages can be obtained in regard to any feature of military medico-surgical work. In fact it is believed that no serious effort has been yet made to tabulate the diseases and wounds, or the treatment and results, which are the outcome of the present war. This information and other valuable data are doubtless in the archives of the *Service de santé*, but will not be made use of, or allowed to become general knowledge, until the war is over.

Val-de-Grâce has received on an average 17 patients a day since the war began, or rather since the battle of the Marne and the German retreat. There were at first, as in other base hospitals, a conspicuous number of tetanus cases, but there have been no cases of this disease here for over six months, or since the time that the antitetanic serum has been in use as a prophylactic. Typhoid fever cases were present in considerable number at the beginning of the year, but only six convalescent cases are now in the hospital. The French have adopted the plan of having certain centers near the front for the treatment of typhoids, and this phase of the organization will receive consideration, as well as comments on the prophylactic vaccine, in the description of this special type of hospital.

As in other base hospitals, in passing through the surgical wards, it is apparent that by far the greater number of serious cases were shell, bullet, and hand-grenade wounds of the head (face and neck usually) and compound fractures of the long bones, with a fair percentage of joint involvement, due to shell and grenade fragments. It was said that there had been quite a number of head cases in which metal fragments were removed from the brain, or incision and drainage done for brain abscess, with apparent recovery until three or four weeks had elapsed, and then suddenly meningitis would develop and carry off most of the cases. Gas gangrene was apparently as prevalent as in other base hospitals having an active surgical service. This condition was treated here by wide incisions and free drainage, with after irrigations of half-strength peroxid of hydrogen, and weak aqueous solutions of either iodin or sodium hypochlorite. Although there were quite a number of stump cases visible, the statement was made that amputation was seldom resorted to in the uncomplicated gas-infection cases, and that the present treatment was eminently satisfactory.

The service at Val-de-Grâce is more or less typical of all the general base hospitals conducted exclusively by French surgeons. Large Government base hospitals are located in every city and town which is near enough to be reached promptly by railway service or automobile ambulances. In view of the law governing the national

Fig. 71.—Ward in a private residence used as an auxiliary hospital. (See page 45.)

Fig. 72.—Ward in a hotel used as an auxiliary hospital. (See page 45.)

Fig. 73.—Japanese Red Cross surgeon and a group of nurses in their hospital, which was formerly a large fashionable hotel. (See page 46.)

Fig. 74.—Madame Carrel and Dr. Alexis Carrel in the grounds of the Carrel Hospital at Compiègne. (See page 50.)

Fig. 75.—A view of the Carrel Hospital. (See page 50.)

Fig. 76.—Hotel de Ville at Compiègne used as a base hospital for medical cases only. (See page 55.)

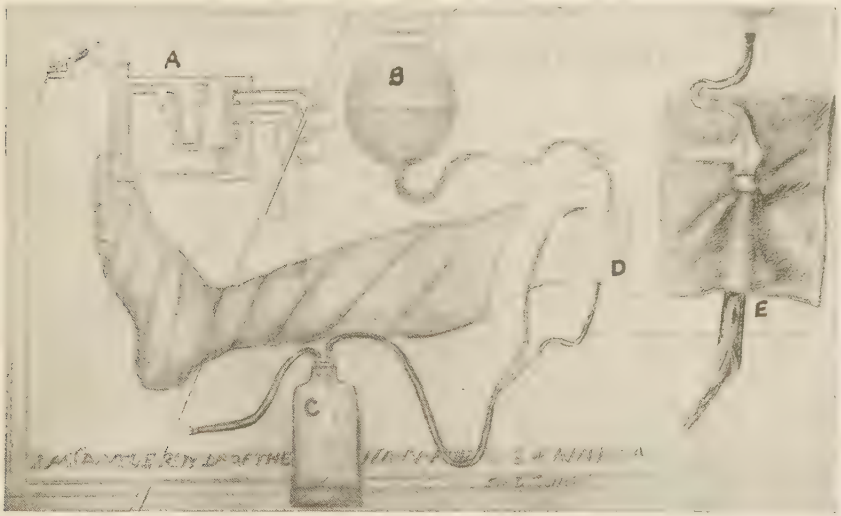

Fig. 77.—Illustrating the combination method of continuous irrigation and suction. (A) Gage showing the amount of suction on the system of pipes. (B) Irrigator containing antiseptic solution. (C) Aspirating bottle connected on one side with the wound and on the other with the suction pipe. (D) Wound sealed up with the exception of the irrigating and suction tubes. (E) A modification of applying the apparatus to the wound in which the irrigation and suction is accomplished through one wound opening. (See page 54.)

Fig. 78.—Showing operating pavilion connected on one side with a house used as wards for the patients and on the other side with truck No. 1. (See page 60.)

Fig. 79.—A closer view of truck No. 1. (See page 60.)

Fig. 80.—Showing the arrangement of valves on truck No. 1 for the control of all steam connections as indicated on the control board. (See page 60.)

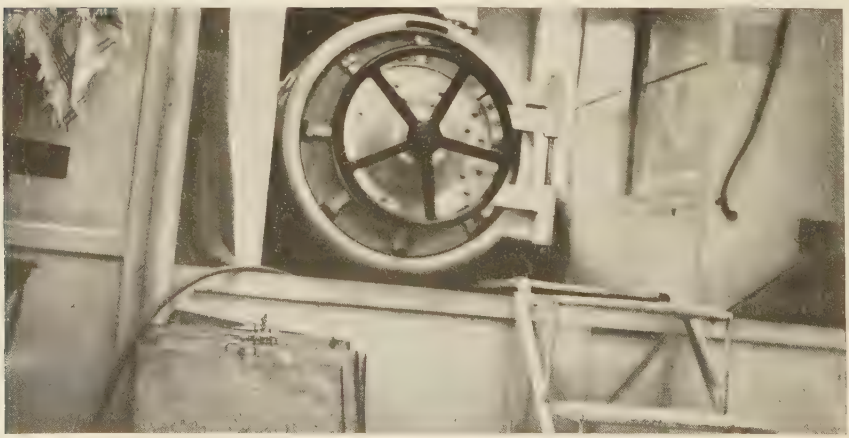

Fig. 81.—Showing the large sterilizer and the opening into truck No. 2. (See page 60.)

Fig. 82.—Showing the interior of the large operating room. (See page 60.)

Fig. 83.—Showing a case which has just been operated upon and a permanent dressing applied. (See page 60.)

Fig. 84.—Truck No. 2 which contains the radiographic outfit. (See page 62.)

Fig. 85.—Showing the connection between the operating pavilion and truck No. 2 by a tarpaulin which also covers the passage to building used for wards. (See page 62.)

Fig. 86.—Showing truck No. 3 which contains the electric-light motor at the forward end and storage space at the rear for operating-room linen. (See page 62.)

Fig. 87.—On a visit with Dr. Carrel to the automobile ambulance unit No. 4. Showing the staff of the surgical unit and also truck No. 4.

Fig. 88.—Showing one of the cars for the transportation of officer personnel. (See page 62.)

Fig. 89.—Showing one of the large motor ambulances of the surgical unit. (See page 62.)

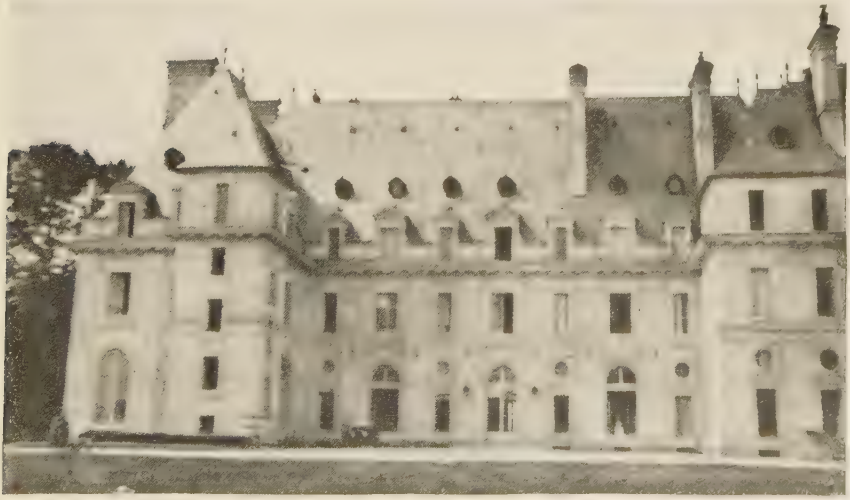

Fig. 90.—One of the many French chateaux used as field hospitals; situated about five miles behind the lines. (See page 63.)

Fig. 96.—First-aid station in the Argonne forest; patients awaiting transfer to the ambulance of a field hospital. (See page 65.)

Fig. 97.—British Red Cross dogs. (See page 44.)

service character of the French military system, there is no necessity for a medical reserve corps, as all doctors and advanced medical students, in war time, are subject to whatever detail the minister of war directs. The expansion of the medical corps is thus provided for, and each doctor is given a detail in keeping with his age, experience, reputation, and specialization.

Until recently the hospital was in charge of Dr. Delorme, the well-known French military surgeon, whose book on war surgery appeared shortly after the outbreak of hostilities. The French Army has for years employed a certain limited number of female trained nurses, but when the war began the Red Cross nurses had to be called on in large numbers, and these latter nurses greatly outnumber the regular military nurses. The Red Cross nurses are derived from the large number of private trained nurses, either active or retired, who volunteer their services for the period of the war.

As already indicated, accurate statistics, with reference to the sick and wounded, are very hard to obtain, and such data as is worthy of consideration gives but small evidence upon which to base conclusions. Now and then certain facts will come to light which are valueless without the correlation of other facts. It is safe to say that until the war is over and all the statistical evidence has been thoroughly digested, it would be fallacious to attempt to draw trustworthy inferences from what has so far been officially announced.

When President Poincaré appointed, in December, 1914, the army commisssion to investigate and report on everything pertaining to army matters, M. Troussaint, the director of the medical department at the ministry of war, reported that up to November 30, 1914, the *Service de santé* had dealt with 489,733 wounded, or approximately 500,000, and these figures were exclusive of deaths on the battle field. Of this number of wounded actually treated in French hospitals, 54.5 per cent were returned to duty within a variable short period after being received; 24.5 per cent were given furloughs during convalescence and have since returned to duty; 17 per cent were still in hospitals, with a prognosis of complete recovery; 1.48 per cent were unfit for further service, and 2.48 per cent had died from the effects of their wounds. There were at this time 3,968 hospitals in commission, containing 360,000 beds, which was regarded as being ample provision for what was to be expected of the *Service de santé*. A French Army surgeon of considerable experience in different phases of this war has estimated that up to July 30, 1915, there had been, including deaths, sickness, and wounds, a fraction over 900,000 casualties on the French side alone. As regards the British service, it has been announced on good authority that 60 per cent of their wounded return to duty. On June 9, 1915, Premier

Asquith announced in the House of Commons that up to May 31, 1915, there had been 258,069 men killed, wounded, or missing in the British Army, viz:

	Killed.	Wounded.	Missing.
Officers	3,327	6,498	1,130
Other ranks	47,015	147,482	52,617
Total	50,342	153,980	53,747

As regards the casualities in the British Navy, the Premier announced that for the same period the total casualties were 13,547, viz:

	Killed.	Wounded.	Missing.
Officers	549	181	74
Other ranks	7,696	2,262	2,785
Total	8,245	2,443	2,859

The Telegraaf, a very reliable daily paper published in Amsterdam, Holland, has carefully analyzed the German official casualty lists so far published, and on June 4, 1915, stated that the Prussian losses alone have reached a total of 1,388,000. This did not include a certain number of Bavarian and other lists which were not considered as yet complete.

In view of what may be the final verdict on the general results of this war, with reference to the sick and wounded, it is instructive at the present time to record that during the Franco-Prussian War of 1870 there were 138,871 deaths in hospitals due directly to wounds, and 328,000 unwounded sick who also died in hospitals. At this time there were 73,000 cases of typhoid in the German Army alone, and of these 7,000 died. In the Boer War the English had 57,000 cases of typhoid with 8,000 deaths. In the Spanish-American War every fifth man who went to war contracted typhoid fever.

Dr. Alexis Carrel's hospital at Compiègne (figs. 74 and 75) is a special surgical base hospital of 60 beds, located only 8 miles behind the lines. Its situation is unique in that no other base hospital of this type is located so far to the front or has the opportunity of developing the special work for which the hospital was organized. The fact of this hospital being so near the front gives it a great advantage in the treatment of wounds, as only 6 to 10 hours elapse from the time a man is wounded in the trenches until he is brought by automobile ambulance to this hospital. A special bid is made for the seriously wounded, and as practically all surgical cases reaching a base hospital are infected, it will be seen at a glance that the position that this hospital occupies offers great opportunities for promptly and

successfully accomplishing whatever surgical procedures are necessary. When it is realized that it usually takes from three to four days, and sometimes longer, for the wounded to reach the large base hospitals, it is then easy to understand the advantage Dr. Carrel's hospital has over the usual base hospital in the treatment of infected wounds.

The new mobile surgical field ambulance unit of the French Army is a development of the same idea as regards instituting prompt and efficient surgical treatment in the field for all character of wounds. The difference between these mobile surgical ambulance units and Dr. Carrel's hospital is that the latter has a full complement of doctors and female trained nurses, with every facility to care for the wounded after operation; while the surgical field units are hampered, so far, by not having the requisite number of trained hospital corpsmen to give the proper attention to the patients after operation.

The Carrel hospital occupies what was formerly the Rond-Royal Hotel and is specially well adapted for the work of a hospital of its character. It is financed partly by the Rockefeller Institute of New York and partly by the Government. Besides Dr. Carrel, who has the rank of a lieutenant in the French Army, there are five other French surgeons who conduct the necessary surgical and laboratory work. In addition to these there is a highly skilled chemist, Dr. H. D. Dakin, of the Herter Laboratory, New York City; an artist, Mr. Tonetti; and two administrative officers, each having the rank of a lieutenant in the French Army. A full complement of Swiss nurses, graduated under Dr. Kocher, of Bern, insures admirable care for the patients, and over all Madame Carrel exercises a constant supervision.

While the hospital organization is primarily for treating the wounded promptly, it has undertaken a special character of research work with reference to developing the most efficient antiseptic for the treatment of infected wounds. All the well-known antiseptics have been tried out in different ways, and Dr. Dakin has compounded, for trial and comparison, 130 different chemical antiseptic combinations. The result of this painstaking experimentation has developed an antiseptic for the treatment of infected wounds which not only unquestionably meets all the present surgical demands, but for clearing up infected and sloughing wounds is practically a specific. Since practically every wound that reaches a base hospital is infected in greater or less degree, it has been more and more apparent to experienced surgeons in this war that a vigorous campaign of antisepsis is to be adopted in the handling of all wounds. The exception to this rule is the comparatively small number of perforating or penetrating rifle-ball or small-missile wounds of the extremities which are usually not infected and heal spontaneously without

requiring more than an expectant line of treatment. In contrast to the surgery of peace, where surgical asepsis is the goal to be sought for, the general surgical treatment in this war has harked back to the days of Lister, with the idea of combating an already present infection in the wounds which demand surgical treatment. Whenever it becomes necessary to operate for conditions under circumstances which insure asepsis, the principles of modern surgical asepsis, instead of antisepsis, are carried out.

The antiseptic developed by Dr. Dakin, and tried out in a thoroughly convincing manner at the Carrel Hospital, is an aqueous solution of 0.5 per cent concentration of sodium hypochlorite and is made as follows: Dissolve in a large bottle 140 grams of dry carbonate of soda with 10 liters of sterile water. Add to this 200 grams of chlorid of lime (bleaching powder) and shake well. After half an hour siphon off the clear fluid into another bottle through a cotton plug or filter paper and then add 40 grams of boric acid to the clear filtrate. This solution is neutral to litmus, is nonirritating and is the proper strength for wet dressings and irrigations. A stronger stock solution of 4 per cent may be made, but the quantity of boric acid to be added must be determined exactly, so that the solution is just acid to phenolphthalein suspended in water; otherwise the solution decomposes very quickly. The solution should be made fresh every three or four days, and the dry stock ingredients should be kept in covered receptacles. Besides its proven efficiency, another point worthy of consideration is that this solution can be made up, even in small amounts, at a cost of only about 5 cents for 10 liters. Dr. Dakin's paper, read at a recent meeting of the French Academy of Sciences and giving the experimental data in detail, is appended to this report. (Appendix No. I.)

As already indicated, this antiseptic is used for wet dressings and as an irrigation. Large infected wounds, particularly those showing a necrotic or gas-forming tendency, are treated as follows: After the surgical condition, such as a compound fracture or a lacerated contused wound, has been treated by incising and clearing the parts of any loose material (foreign), drainage is accomplished in the usual way by the use of the fenestrated drainage tube introduced into the depth of the wound when thought necessary. In addition to this, a small soft-rubber fenestrated tube is introduced into the depth of the wound and allowed to protrude beyond the surface for 4 or 5 inches. The wound is then lightly packed with gauze pads saturated with the antiseptic solution and completely covering the small rubber tube in the wound, except that part that protrudes. Several larger gauze pads are now placed over the wound and secured lightly by a bandage, while the small rubber tube protrudes outside the dressings. This small rubber tube is now connected with a Murphy drip appa-

ratus containing the antiseptic, which latter is allowed to enter by slow drops, usually about 30 to 50 drops a minute, the rapidity depending on the character and gravity of the infection. These dressings are renewed once or twice a day, according to indications, and the drops kept up as long as the infection lasts, the condition of the wound and the constitutional manifestations being the general guide in carrying out the treatment. As the infection subsides the tube is removed and moist pads merely left in the wound at the time of the daily dressing.

Another method of applying this antiseptic to the wound, which has also given very satisfactory results, is to inject into the wound from 5 c. c. to 10 c. c. of the antiseptic every one or two hours through the small protruding rubber tube. The amount to be injected depends on the size of the wound, while the interval between injections is made longer or shorter, depending on the character of the infection. It is considered advisable to keep the dressings more or less saturated for the first 48 hours, and after that the general condition of the wound and the patient will indicate the proper course to pursue with reference to further treatment. By this method wounds are usually dressed every morning, and as the infective process subsides a less energetic treatment is instituted. This method is specially applicable to wounds about the face and neck and also in large lacerated or contused wounds of other parts. A combination of continuous nightly irrigation with daily injections is sometimes used, particularly if it is found that by the use of injections at night the patient's rest and sleep is seriously interrupted.

When properly carried out this treatment will usually practically sterilize a wound in from three to four days, depending on the character of the wound and the extent of the infective process. When the wounds are treated early and the foreign infective material removed they rapidly clear up and have sometimes been actually closed by suture after several days, with subsequent uncomplicated healing of the wound. Amputation for badly infected compound fractures has been very rarely resorted to when this method is used, and has been only performed when complicated by serious blood-vessel injury which prevented proper nutrition of the part.

A very valuable feature of this antiseptic is its remarkable power of quickly separating and dissolving necrotic material in a wound. It very frequently happens in the wounds of modern warfare that a certain amount of devitalized tissue in the wound becomes necrotic and usually remains for a longer or shorter period as a medium for saprophytic bacteria and consequent prolongation of the infective process. With an antiseptic which rapidly cleans the wound of this necrotic and sloughing material, the surgeon has a most important adjunct in satisfactorily treating this class of wounds. In view of

the fact that the gas-forming anaerobic bacilli (*perfringens*) undoubtedly thrive best in the presence of devitalized, necrotic, or sloughing tissue, the value of this antiseptic in dealing with this character of infection will at once be appreciated. The use of this antiseptic and its mode of application in the treatment of serious and complicated wounds has been successfully demonstrated many times, not only in Dr. Carrel's hospital but also in a number of other base hospitals and field-ambulance units.

A combination continuous irrigation and suction apparatus (fig. 77) has been used quite often at the Carrel Hospital in the sterilization of certain perforating wounds of the extremities, particularly those due to the rifle ball, when the X-ray shows no foreign body in the wound. The general principle of this suction apparatus is along the lines of through-and-through drainage, with the antiseptic entering by one drain and being withdrawn, along with the septic wound secretions, by continuous suction applied to the other drain, which latter is usually dependently placed. This method of treatment, when applicable, has certain manifest advantages. After the apparatus has been correctly applied the wound does not have to be dressed again until the infection has cleared up. This, of course, is highly important in connection with compound fractures and keeping the parts at rest.

As carried out at the Carrel Hospital, the wound of entrance and exit are only enlarged sufficiently enough to remove any foreign (metal) or loose material (bone) and to admit of the introduction of the two fenestrated drainage tubes into the depth of the wound. The wound around each tube is then completely sealed up by means of a small piece of rubber tissue secured tightly around the tube and glued to the surrounding skin with collodion. A thin layer of gauze is also glued with collodion over the rubber tissue to the skin so as to reenforce the rubber tissue in sealing the wound. One of the drainage tubes is now connected to a Murphy drip apparatus, as indicated above, while the other tube is connected by a long piece of rubber tubing to a large aspirating bottle underneath the bed. This bottle is continuously exhausted of its air, on the same principle as the vacuum bottle in aspirating the chest, by means of a special water-suction apparatus which operates in a distant room. This suction apparatus, which works on the principle of continuously flowing tap water, is connected with a system of small lead pipes located in the ward. These small lead pipes run throughout the ward and are secured to the baseboard near the floor, giving off small branches, controlled by set screws opposite the head of each bed, and these branches are connected to the aspirating bottle by rubber tubing.

As regards the use of the solution of hypochlorite of sodium in the treatment of wounds, it is to be noted that the French surgeons

have for years been partial to a solution of this drug called "*Eau de Javelle*," but the latter is by no means the same antiseptic as the Dakin fluid described above. "*Eau de Javelle*," while possessing excellent antiseptic properties, always contains a quantity of practically free chlorin and is decidedly alkaline in its reaction. Being a patented preparation, it contains other unknown ingredients which are doubtless harmless in themselves, yet the combination as a whole has proved to be far less efficient than the Dakin fluid. Unless the latter fluid is carefully made and applied as described above, it will not give the thoroughly satisfactory results which have obtained in the Carrel Hospital and other places where it has been carefully prepared and painstakingly used.

The equipment of the Carrel Hospital is complete in every department of the work. Besides the usual hospital paraphernalia, there are special rooms for research work, including a special operating room for animals. Special reports are made from time to time to the Rockefeller Institute with reference to the progress of the research and other work, and the minister of war is also keenly interested in the work being done at this hospital. While possessing only a comparatively small number of beds, the service is kept quite active by evacuations to convalescent hospitals when the patients no longer need special attention, and the capacity of the institution has been found to be ample for the special character of the work performed.

There is another type of special base hospital at Compiègne, located in the large and beautifully situated Hôtel de Ville, once occupied by the first Napoleon as a summer home (fig. 76). It has a capacity of 450 beds, and only strictly medical cases are treated. Since the German retreat, after the battle of the Marne, it has been a special center for treating typhoid fever cases coming from this sector of the front and drawing its patients from about two army corps. In addition to this, articular rheumatism, which was prevalent during the winter months; the common contagious diseases, mumps, measles, scarlet fever, whooping cough, and diphtheria; malaria, in different phases of the disease; pneumonia of both types, in small number; tuberculosis of the lungs, which is of rather infrequent occurrence; latent syphilitic manifestations; obscure intestinal disorders, rarely a case of tropical disease among colonial troops; and very rarely a case of undefined benign cerebrospinal disorder, represent the general run of patients treated at this hospital.

From November, 1914, to March, 1915, there was quite a noticeable epidemic of typhoid and the allied fevers, paratyphoid A and B. Only such cases were included in this group in which the organism was demonstrable by blood culture. No statistics were available to indicate the number treated up to the present time, but the general character of the infection was mild in the great majority of cases.

In January, 1915, the French Army adopted compulsory typhoid vaccination. The vaccine used, known as the "Dopter" serum, is not a mixed vaccine, but is intended for protection against the Eberth bacillus only. According to all reports, it has no prophylactic value against the paratyphoids.

After April, 1915, there was quite a noticeable dropping off in all cases of this group, both typhoids and paratyphoids; so that by August, 1915, only convalescent cases, and rarely a new case, were present in the wards. At times it was noticed that the character of the undifferentiated disease was the same, both in those who had received the required four doses of vaccine and in those who had received none. Throughout the epidemic the typhoids and paratyphoids were about equal in number, and ofttimes the only diagnostic difference between these fevers would be the recorded demonstration of the particular organism in the blood. Sometimes it was noticed that cases of typhoid developed after the patient had received from one to two, and even three, doses of the vaccine. Rarely was typhoid demonstrable in those who had received four injections; although paratyphoid, as shown by blood culture, was as common among this class of patients as in those who had received no vaccination whatever. No reliance was placed on the diagnostic value of the Widal reaction in any patient who had received the vaccine, as agglutination was invariably present in those who had received even one injection.

From a careful review of many of these and other cases, it would appear that while the incidence of typhoid fever in the French Army is markedly less in proportion to the number of men than was present in former campaigns, yet it is far from being wiped out as is the case in the American Army and Navy. There can be no question that the disease is milder, and apparently less liable to complications, than was formerly noted. It would thus appear that the prophylactic vaccine not only has had a certain, though as yet undetermined, influence in checking somewhat the prevalence of the disease, but also is doubtless responsible, in a measure, for the general run of mild and uncomplicated cases. Just what influence the improved hygienic conditions in the field have exerted on the prevalence and character of the disease would be hard to determine, and it would be rash to form an opinion until all the data and statistics are available. As regards the incidence of paratyphoid fever, it would seem scarcely to be influenced as yet by any measures so far taken by the French Army, although it is not unlikely that the improved field hygiene has contributed its share toward preventing this, as well as other diseases. It would be difficult to draw accurate conclusions at this time as regards the incidence of typhoid fever in the British Army. Although the general statistical material is more accessible than in the French Army, there is no compulsory typhoid vaccination in the British

Army; and it has been stated on good authority that only about 70 per cent of the entire army have received the injections. Up to March, 1915, there had been 650 cases of typhoid in the British land forces, and the indications are that it was a more severe type of fever than in the French Army.

As regards the organization of this hospital and the general treatment of all medical cases, there is nothing to record which indicates anything different than would be found in a well-conducted American institution. There are quite a number of these special hospitals for medical cases, and it would seem that there is no doubt as to the value of having specialized institutions for medical and surgical cases whenever it is practicable. Not all practitioners are surgeons, and the French were quick to realize that much better general results would be obtained by utilizing the skillful internists in these special hospitals. It is not to be understood that either the medical hospital is without its surgical consultant or the surgical hospital without its internist. While specialization has been fostered, the organization of each hospital is well balanced and the patients receive every care and attention.

A few special hospitals for the treatment of the common epidemic contagious diseases are located at points convenient for canal-boat transportation. While the French and British Armies have had their share of this class of cases, there has been no manifestation in the way of a cerebrospinal epidemic, nor has there been any indication of cholera, typhus fever, or plague. For the large number of men actively engaged, estimated at something over three million, the incidence of disease in the French Army has been remarkably low, and this, together with the general good health and robust appearance of the troops, has been the subject of much favorable comment.

The development, by the French Army surgeons, of a mobile field surgical ambulance unit, intended for the prompt and energetic treatment of all classes of wounds, is a recognition of the great importance attached to accomplishing efficient surgical intervention in the field before any primary infection has had a chance to spread; and also to obviate, by more or less permanent dressings, any secondary or spreading infection which has too often occurred where certain classes of wounded have had to be transported for considerable distances to the base hospitals. The usual rule heretofore in field surgical work has been to avoid as far as possible the performance of any complicated operations, and only such major operations have been performed as were imperatively indicated to save life, such as for hemorrhage, absolutely necessary amputations, and perforating or penetrating wounds of the abdomen or cranium.

The reason for this has been twofold—first, in campaigns of any magnitude the field hospital surgeons have found that to do equal

justice to the large number of wounded coming under their care it has been impossible, with the exceptions noted above, to do more than render prompt inspection of every wound and the application of some form of reliable dressing to meet the immediate demands of the particular case before the latter is transported to a base hospital for major operative treatment; secondly, the necessarily restricted capacity of a field hospital, the comparatively small number of surgeons and attendants, together with the limited surgical and other supplies, have made it impossible to attempt surgical procedures which would necessitate keeping patients for any length of time. A field hospital has always had to evacuate its wounded promptly in order to fulfill its mission as a mobile unit of military formations in the field. Under these circumstances it may not only at any time be called upon to advance or retreat, but must be in readiness to receive at all times such numbers of wounded as may be sent in from the firing line or trenches. As a consequence of endeavoring to perform this function for troops at the front it has been learned in the hard school of experience that only the minimum number of such serious cases, where the attempt to move would obviously cause death, are to be retained. These latter cases are usually the results of life-saving operations, rapidly performed, or when profound shock, due to large mutilating wounds, prohibits further transportation until the patient has sufficiently recovered to stand the journey.

The history of all field surgery so far has been that radical operations performed under the second condition have greatly increased the mortality of war surgery. The cases thus treated have to be retained and are subjected to the necessarily meager after-treatment and attention or are transported to a base hospital a few hours after operation, in either case the resisting power of the patient being considerably lowered as a result. In addition to this, the usually hurried character of the work is not conducive to efficiency in connection with prolonged or complicated operations nor are the conditions in field hospital work ideal with reference to carrying out aseptic operations or the preventing of infection during the after-treatment.

The general idea so far carried out in military surgery has been along the lines of a graded attention to the wounded. Commencing with the application of the first-aid dressing on the firing line or in the "refuge spots"; passing through the first-aid station, where the wounded are grouped, antitetanized, tagged, re-dressed, and arranged for transportation; on back to a field hospital, where the wounds are inspected and more elaborate measures taken, such as the introduction of drainage tubes when necessary, or the application of a more pretentious, if not permanent, dressing; until, finally, a base hospital is reached, where such radical operations are performed as

are indicated. This general working plan has been found by experience to result in less confusion as regards the details to be carried out and in less detriment to the general welfare of the average patient. The whole system is the result of a compromise, on the one hand, between the ideal treatment of wounds in a well-equipped civil hospital under normal conditions, and on the other hand the ofttimes overwhelming amount of work to be performed under the very trying conditions of urgent war surgery in the field.

With the idea of effecting a further compromise toward bettering the average conditions under which fieldwork has to be performed, the new French mobile surgical field ambulance unit is a well-planned effort in the right direction to obviate certain of the difficulties usually in the way of more pretentious field surgery, and with a view to bringing about better general end-results than have heretofore obtained.

As already indicated, this surgical ambulance unit proposes to render efficient field surgery of a more advanced nature than the ordinary field hospital, and in doing so it partakes somewhat of the character of a base hospital with a limited number of beds. The general idea is that this unit is usually to be situated in a small village or protected spot as close to the trenches as is permissible with safety to the patients, and in this location carry out its function to the limit of its capacity. Here not only are grave life-saving operations to be performed, but all classes of wounds are to be thoroughly cleansed and then dressed with whatever permanent dressing is necessary for the individual case. When its capacity is reached it would no longer continue to receive patients, but merely continue the after-treatment in those cases already operated upon. By establishing quick lines of communication toward the rear it hopes to keep the patients well provided for in every way, and incidentally gradually to evacuate to sanitary formations farther back such convalescent cases as are able to travel. By this means it is expected to be able to treat efficiently a certain large number of wounds early enough to prevent the ravages of infection, and thereby obtain better statistical results as regards the saving of life and limbs.

The automobile has figured to a large extent in every feature of the present war, and in no department of the army has its influence been more decidedly shown than in the sanitary service. The increasingly large number of motor ambulances for quickly transporting the wounded, the numerous automobile transports for medical and other supplies to advanced sanitary formations, the general utility of the motor car in establishing quick lines of communication, and lastly, the development of the automobile surgical field ambulance unit, all indicate the far-reaching and progressive usefulness

of the motor car in the general organization for the care of the sick and wounded.

This surgical ambulance unit (figs. 78–89) comprises eight large and two small vehicles, as follows: Four trucks of 3½ tons each (Nos. 1, 2, 3, and 4 in fig. 98), two cars for the transportation of the officer personnel and their trunks, and four large automobile ambulances for the transportation of the hospital attendants of the unit when changing position, and also for the evacuation of the wounded or carrying supplies when the unit is functioning.

On truck No. 1 is installed the following: A steam generator or boiler in the back part of the car that feeds nine distinct steam valves, which are enumerated on the control board. These valves correspond to the heating appliances, the boilers, the large steam sterilizer, the spiral-tube water heater, the steam jets for general disinfection, the washing boiler, and an emergency valve. The forward end of this car communicates by a side opening with the operating pavilion, and contains the hot and cold tanks of sterile water, a very large steam sterilizer or autoclave, which latter is equipped with metal racks for the sterilization of 12 complete sets of instruments for 12 successive operations. This sterilizer is the same type as used in civil hospitals and can be used uninterruptedly day and night.

Adjoining this large sterilizer is a small one for emergency purposes. Above this are kettles for keeping sterile water warm, a metal box for sterilizing gloves, and a linen heater. On one side of the small sterilizer is a metallic cupboard divided into compartments, which latter contain baskets of surgical instruments and dressings for immediate use. There are also two large reservoirs for water, each containing 300 liters, mounted on the roof of truck No. 1. These reservoirs are filled by means of a special aspirator and long rubber hose. A speaking tube in the operating room permits of communicating verbally with the chauffeur in charge of the boiler.

At the time of installation, truck No. 1 is brought up close to the opening in the operating pavilion so that it fits snugly against the corresponding opening in the forward end of the truck. The operating pavilion is 45 feet long by 18 feet wide and is constructed of strong cross panels supporting wide pieces of light boards, all of which are interchangeable. It contains three intercommunicating rooms: one room for cleaning the wounded on arrival, one room for septic cases and general dressings, and one large room with three operating tables. By this arrangement four groups of surgeons can operate simultaneously and under excellent aseptic conditions. The partitions between the rooms consist of the same interchangeable material as the rest of the building and can be rapidly taken down or interchanged, so that the number or the size of the rooms can be

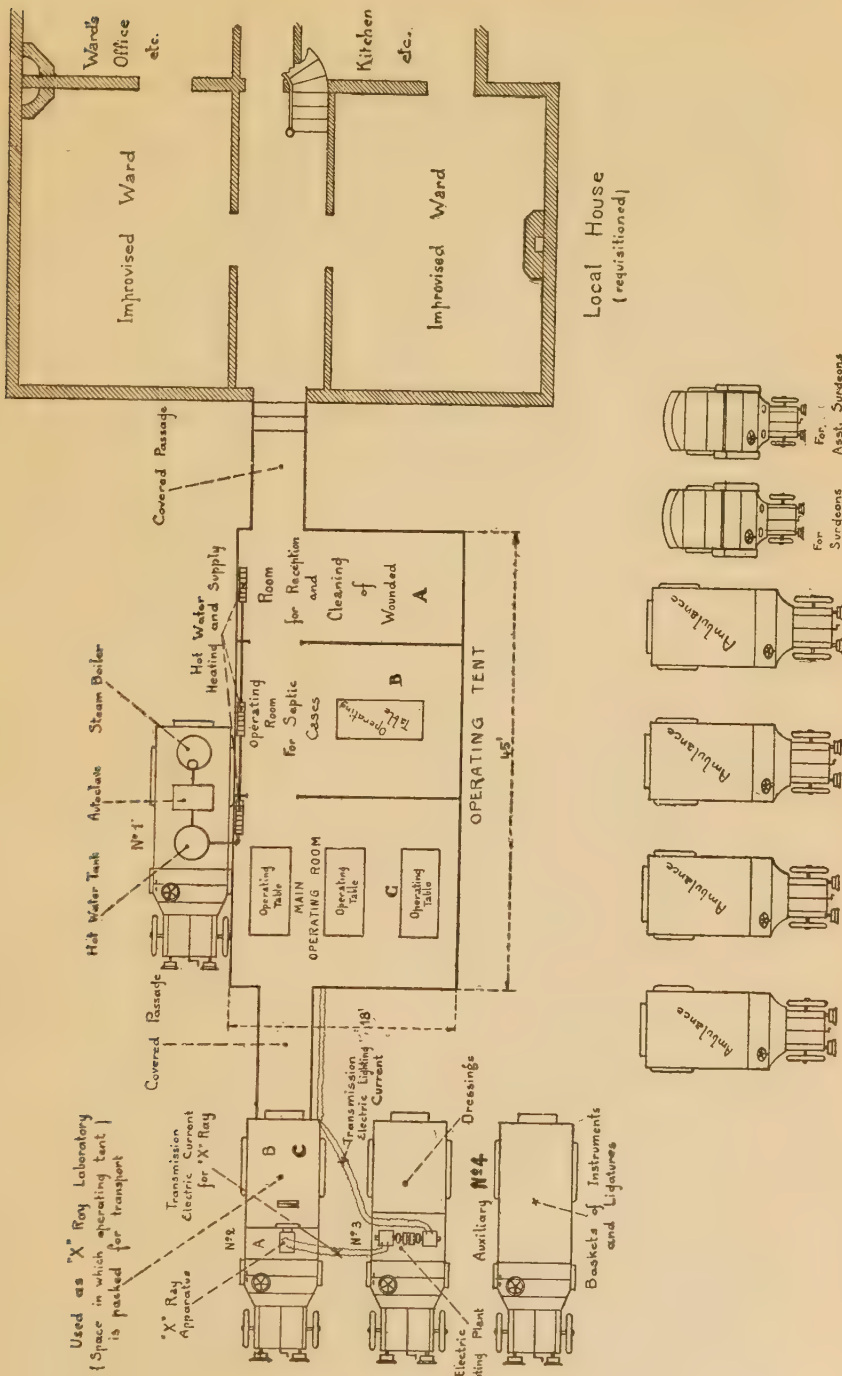

FIG. 98.—Ground plan of surgical field hospital in operation.

changed as desired. The outside of the building is painted green and the inside white. The roof is composed of strong canvas stretched over a central support and securely lashed to the sides of the building. A number of small transparent celluloid windows around the side of the building give an abundant light.

A tarpaulin passage, with communicating floor, connects the operating pavilion with truck No. 2, which contains the very complete radiography apparatus and dark room. Everything for conducting this line of work has been minutely provided for, and the internal arrangements of the truck admit of a very ingenious and close method of storing all the X-ray paraphernalia when the unit is changing position. In the back end of this truck is also stored the entire operating pavilion when the latter is to be moved.

Truck No. 3 contains at the forward end a large electric motor, coupled up with the automobile engine, which furnishes the power for the X-ray apparatus and for the necessary lighting at night. The back end of this truck is divided into a large number of compartments, on each side of a central aisle, which are used for storing all the operating-room linen, the bandage material, and splints. Truck No. 4 is also divided into a large number of compartments containing baskets of instruments, medicines, ligatures, dressing materials, and operating-room supplies of all kinds. Every available space in each truck is utilized for storing purposes and all the compartments are numbered and inventoried.

The installation of this unit contemplates the use of a local house, or several buildings, capable of providing space for a hundred beds, and in addition a series of rooms for the general personnel of the unit. Supplies of all kinds are locally requisitioned when possible, and the food is prepared by regular cooks enlisted for the purpose. The collapsible metal frame beds, each with mattress, blanket, and sheets, are packed in the ambulances when the unit changes position.

The personnel of this unit consists of 4 surgeons, an internist, a radiographer and pharmacist, and a general executive or administrative officer. The hospital attendants are supposed to number from 50 to 60, but so far it has been very hard to recruit even a much smaller number of sufficiently trained men for each unit to carry on the work successfully. The first of these units was sent into the field on May 10, 1915, and at this time (Aug., 1915) there are 22 units in all, scattered along the front. It can not be said as yet that they have fully come up to expectations, as the organization of the hospital corps personnel is far from complete. However, it has been only a comparatively short time since they have been in use, and as time goes on these units will doubtless considerably improve on the results so far obtained. As far as the special character of the work is concerned, it may be considered that they are still in the experi-

mental stage, and for this reason it is too early to form an opinion of their real value.

Another type of field hospital is the one which occupies a large building in some special situation near the front, usually within 5 miles of the line. The commodious and well-appointed French chateau, of which there are a large number scattered throughout the country, is the favorite site for this type of hospital. Being well supplied with water and the general equipment which is to be found in a large establishment of this kind, it offers every facility for treating and housing a large number of patients, depending on the size of the building (fig. 90).

The work performed at these hospital units is of the kind already alluded to in connection with a standard field hospital. Here the wounded are regrouped and the serious cases attended to at once. Such operations as for perforating and penetrating wounds of the abdomen or cranium, and also for hemorrhage, are performed immediately. It is here that one sees the bayonet and other thrust wounds that do not cause immediate death on the field. The mortality in this class of work is very high, for the reason that the patients are already shocked as the result of their wounds and the necessary journey from the trenches to the field hospital. With the added shock of an operation performed as a life-saving measure it is easy to understand the high death rate.

Once the serious cases are out of the way attention is given to the other group of cases. This consists of removing all dressings and inspecting the wounds, facilitating drainage by enlarging the wound and the introduction of drainage tubes when considered necessary, giving antitetanic serum to every case which has not already received it at a first-aid station, the application of well-fitting temporary splints, and carefully redressing every case under antiseptic and aseptic precautions.

As in all other military sanitary formations, iodin, preceded by benzin or alcohol, is universally used in the preparation of the skin and wound for operation. The wounds are thoroughly cleaned out with alcohol, ragged tissue removed, but no effort is made to search for foreign bodies, only such pieces of clothing and metal being removed as can be easily seen and reached. A number of these units are beginning to use the Dakin fluid for moist temporary dressings, and reports indicate that it is giving very satisfactory results. As soon as the condition of the patients will stand transportation they are evacuated to clearing hospitals for further transportation to the base hospitals in the rear. Before evacuation each case is carefully tagged, and the character of the dressing or operation indicated on the card (figs. 92 and 93).

Another type of French field hospital attempts to push a little farther toward the front than the chateau, or fixed building, type of hospital. This type corresponds in general to the one in use by the United States Army except that the tentage is of the large variety, with only a few smaller extemporized tents for cooking and housing the personnel. These hospitals are located in a protected spot with a water supply, sometimes within 2 miles of the front, and the average capacity is about 40 beds (fig. 94). Here the same character of work is performed as in the chateau type of field hospital, but with the added advantage of being able to move at short notice to positions where its usefulness would be increased. The large main tents, usually two or three in number, consist of canvas stretched over a central ridgepole and having lateral wooden uprights at the corners and along the sides. It is really a double tent, as the entire inside of the structure is lined with canvas and there is an intervening air space of about 4 inches. The windows along the sides consist of a translucent light material, which is oiled, and in cold weather secured over the openings in the canvas.

The numerous first-aid stations are situated, as already indicated, as close to the firing line or trenches as is compatible with a certain degree of safety to the patients. Often they are exposed to shell fire, but, wherever located, the attempt is made to take advantage of every form of local protection. They are usually situated from a half to 1 mile behind the lines in houses which have usually been partly destroyed by shell fire (fig. 95). Water is usually to be found in or near these structures, and when dangerous shell fire threatens the wounded are removed to the cellar. The work here is of a very hazardous nature, as not infrequently the personnel of a first-aid station has been wiped out almost completely by the bursting of shells in the immediate vicinity. The wounded received here are given the subcutaneous injection of antitetanic serum, the first-aid dressing is reenforced and the necessary extemporized splints applied. Those that are able to walk are assembled and directed toward a field hospital in the rear. The stretcher cases await the arrival of the motor or horse ambulance units, to which latter they are carried and the stretchers then returned to the first-aid stations.

The ambulances can not usually approach very near to the first-aid stations without drawing the fire of the enemy, and as a consequence they not infrequently work at night or assemble at a designated point where they can not be seen. Here they receive the wounded, as indicated above, and transport them to the field hospitals toward the rear.

As already pointed out, when a soldier is wounded he crawls, or his comrades carry him, along a communicating trench, or "*boyau*" as it is called, to a "refuge spot" located behind the first reserve trenches. This "refuge spot" may be a covered space dug out of

Fig. 99.—View of part of the front of the American ambulance hospital showing the automobile ambulances drawn up in line. (See page 66.)

Fig. 100.—View in front of the hospital at the time of the visit of the President of the French Republic. (See page 66.)

Fig. 101.—Arrival of wounded at the American ambulance hospital. (See page 68.)

Fig. 102.—Type of heavy motor ambulance used at the American hospital and designed to carry four patients. (See page 68.)

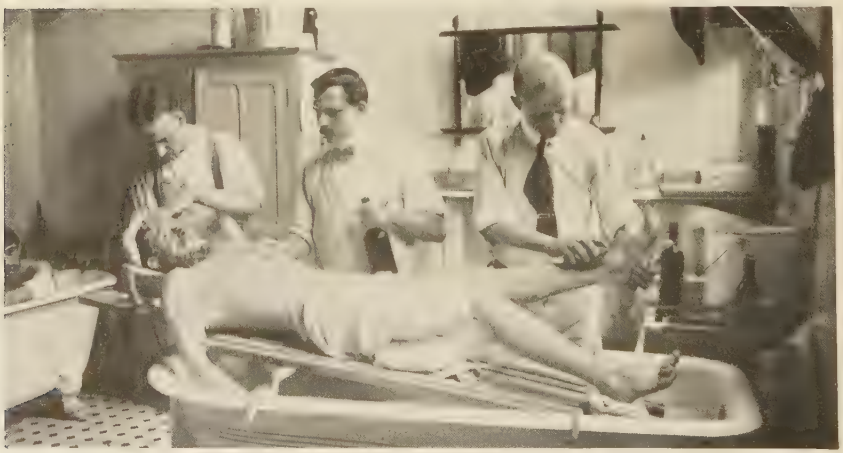

Fig. 103.—Bathing room at the American ambulance hospital where each patient receives a thorough scrubbing upon arrival. (See page 68.)

Fig. 104.—Showing original dressing on a large shell wound, resulting in a compound comminuted fracture of the lower third of the left femur, which proved to be a typical advanced gas- bacillus infection when the dressings were removed. This patient was received four days after being wounded, and the dressing shown in the photograph was applied in a field hospital three days before arrival at the American ambulance hospital. (See page 68.)

Fig. 105.—One of the wards on Dr. Blake's service showing trestle work over the beds for applying overhead extension or suspension. (See page 69.)

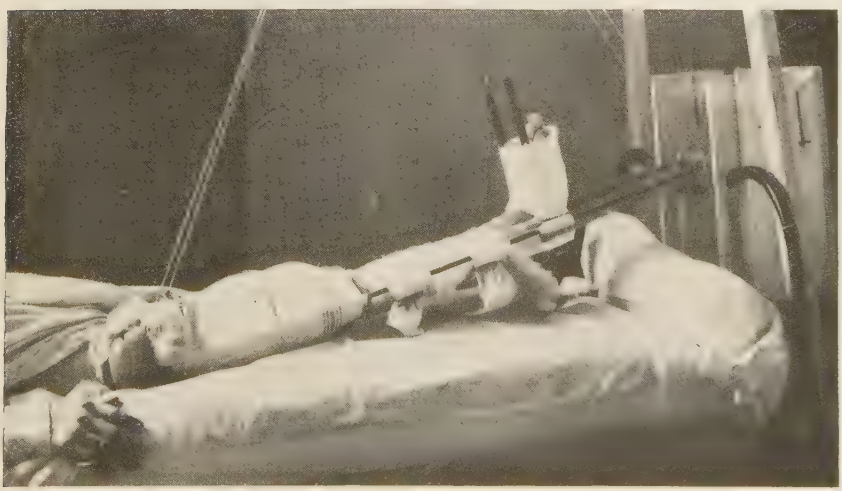

Fig. 106.—Showing Blake's splint applied to a compound fracture of the middle third of the femur with openings above and below for drainage. (See page 69.)

Fig. 107.—Piece of shell in left chest which gave rise to an abscess. Incision and drainage, with removal of the foreign body, resulted in a cure. A curious feature of this case was that both before and after operation the chest was tapped several times and the semipurulent fluid removed was a pure culture of an anaerobic gas bacillus. A culture of the abscess at the base showed a mixed infection with a predominance of anaerobic bacilli.

Fig. 108.—An improved model of Dr. Blake's splint for the right femur. (See page 69.)

Fig. 109.—Showing a very extensive shell wound, resulting in a compound comminuted fracture of the middle third of femur treated by interlocking V-shaped ends of fragments. The limb is put up in an early model of the Blake splint with one of the bars bent outward to facilitate dressing the wound. (See page 69.)

Fig. 110.—X-ray picture of the preceding case, taken after operation, showing the fragments secured by the interlocking "Vs" at the end of each bone. Drainage tubes are shown in position.

Fig. 111.—Sliding cradle used, with extension from the ankle, in the treatment of compound fractures of the bones of the leg. (See page 71.)

Fig. 112.—Another method of using the Blake splint. (See page 71.)

Fig. 113.—Method of treating compound fractures of the leg on the Harvard service.
(See page 70.)

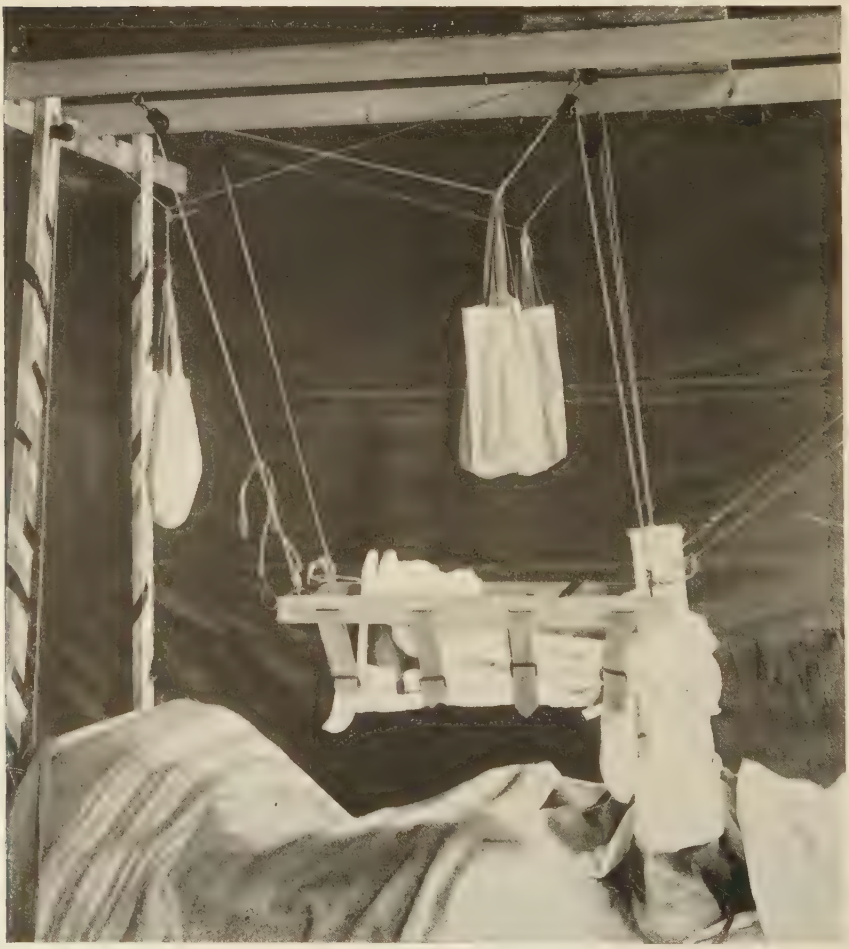

Fig. 114.—Showing the arrangement of the overhead extension apparatus used by the Pennsylvania unit in the treatment of an infected compound comminuted fracture of the upper femur with involvement of the pelvic bones. Continuous irrigation was practiced in this case.
(See page 70.)

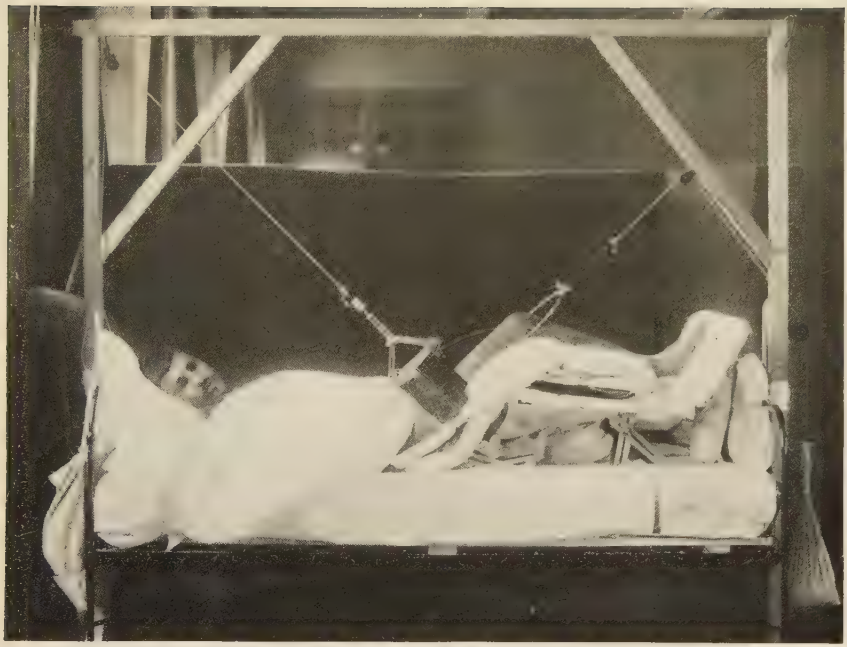

Fig. 115.—Showing the use of Steinmann pins in the treatment of multiple simple fracture of the middle third of femur. (See page 70.)

Fig. 116.—Compound comminuted fracture of the lower third of right leg, the result of a high-explosive shell wound, involving ankle joint and foot. Treated satisfactorily in a modified Blake splint, with extension from an anklet secured around dressing. The discoloration shown in the photograph is due to the silver-nitrate solution used to control the specially virulent infection. (See page 71.)

Fig. 117.—Compound fracture of middle third of humerus treated by overhead extension. This patient had so far recovered when this photograph was taken as to be able to get considerable voluntary motion out of the elbow joint. (See page 71.)

Fig. 118.—Compound fracture of the lower third of the humerus and of the elbow joint, the result of a high-explosive shell wound. On admission, four days after receipt of wound, the entire arm was swollen and edematous, temperature 104° F., and patient had a septic appearance. At operation the wound of the elbow was enlarged and a number of small pieces of broken olecranon were removed along with small bits of shell. Two openings were made for drainage above the elbow (catheter seen in openings). Arm put up in overhead extension with daily irrigations and wet dressings until infection had completely subsided. Patient was entirely comfortable; the wound could be dressed with ease and arm remained extended for twelve days. (See page 71.)

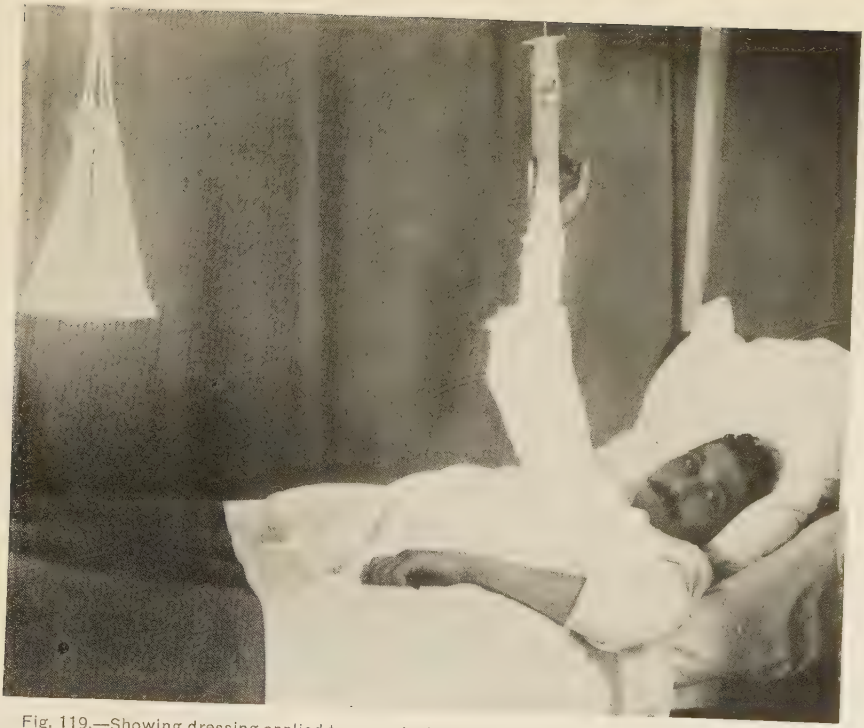

Fig. 119.—Showing dressing applied to wound with arm in extension (same as preceding case).

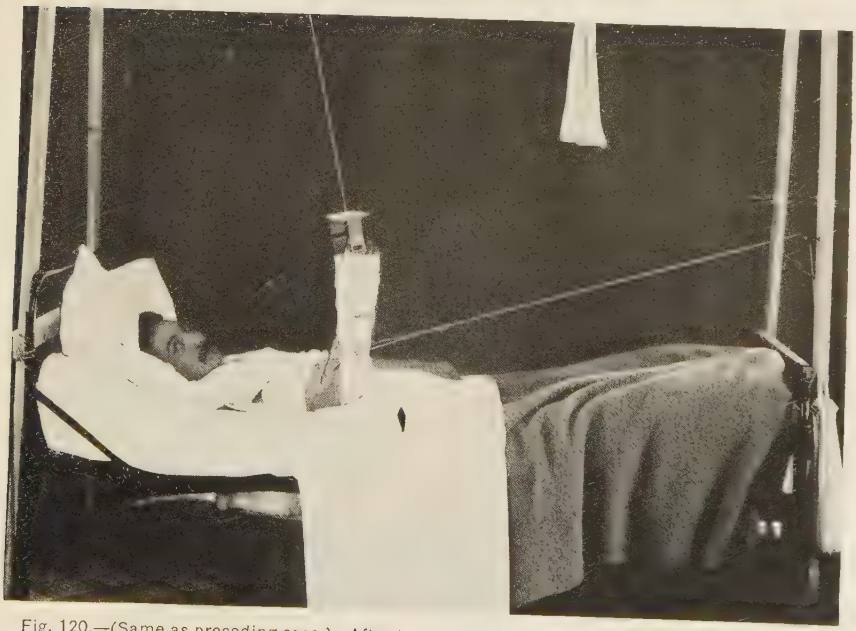

Fig. 120.—(Same as preceding case.) After twelve days, and the subsidence of the infection, the elbow was gradually and painlessly brought to a right angle (three days), and then direct extension was applied at elbow by means of a wide band, arranged in a figure-of-eight around bend of elbow, to which the extension cord was attached.

Fig. 121.—Showing the result of treatment, by the overhead extension method, of an infected compound and extensively comminuted fracture of the middle and upper third of the humerus, caused by a rifle ball at close range. The alinement of the bone is perfect and the patient regained entire use of the arm. (See page 71.)

Fig. 122.—A method of treating a compound fracture of the humerus, by extension and abduction, as used in some cases by the Harvard unit. (See page 72.)

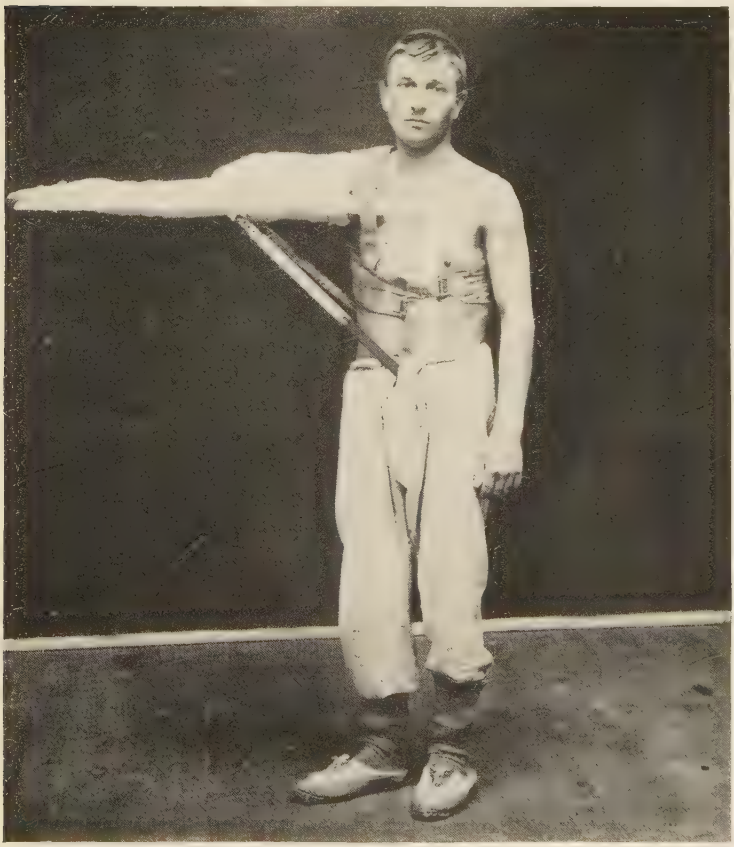

Fig. 123.—An ambulant splint used by the Harvard unit in treating some cases of compound fracture of the humerus in extension and abduction. (See page 72.)

the side of the *boyau* or it may be a natural protected depression in the ground. Here the *auxiliaire* doctor and the attendants apply first-aid dressings, and at opportune moments the wounded are conveyed on stretchers along the winding *boyau* to the point where it ends along a hillside or a screened depression in the ground. This screened or protected area is the collecting place for the wounded from the trenches. Unless the end of the *boyau* is favorably situated, great care has to be exercised by the stretcher bearers, or "*brancardiers*" as they are called, in conveying the wounded to the first-aid stations. The work of the *brancardiers* is justly regarded as the most hazardous of all military routine work. They are constantly exposed to concentrated projectile fire and the mortality among them is very high. They not infrequently volunteer to secure at night the wounded in front of the trenches who have fallen in an assault during the day, and they make every effort to convey the wounded promptly to the first-aid stations.

The first-aid package, carried by every soldier, is practically the same as that of the United States Army, with the exception that it contains a small ampoule of iodin protected in a metal box. Full directions are written on both the outside and inside cover of the package. Not infrequently the soldiers will purchase from a canteen extra packages and ampoules of iodin. As regards the British service, the same general principles obtain throughout as in the French service with reference to the care of the sick and wounded (fig. 97).

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PART III.

BASE HOSPITAL WORK.

The general and special types of base hospitals have already been described, and it only remains to discuss in detail the character of the work usually performed in a large surgical base hospital located an average distance from the fighting zone. The strictly medical work of a base hospital presents nothing to call for special consideration outside of what has already been mentioned in a previous chapter of this report. It is practically only in war time, however, that the military surgeon encounters the wounds due to projectiles, and it is, of course, only during these times that he is able to develop advanced surgical ideas, with reference to the best technic to adopt in order to secure the best results in the treatment of the wounded. Hence it is that after each war of any length new lessons are learned in the hard school of experience, and lessons which could be learned in no other way, so that the military surgeon emerges from the conflict with an added store of practical knowledge as regards the surgery of war. It is for this reason that a detail description of the work of an average base hospital is chosen, as it is practically only here that the higher surgical war problems are solved.

The American ambulance hospital at Neuilly, an offshoot of the long-established American hospital of Paris, is an active surgical base hospital of 570 beds, nearly all of which are continuously occupied. The service is an especially active one, in that the convalescent cases are evacuated to an *auxiliare* hospital as soon as their condition will warrant it. It is the largest strictly surgical base hospital in France, and while it does not do quite as much surgical work as some of the larger general base hospitals already mentioned, it is safe to say that the amount of work done here would represent a fair average of the work encountered elsewhere, as regards the general run of war surgery. In other words, the surgical experience derived from serving in this hospital would certainly give as good an opportunity for treating all character of wounded as could be found in any other base hospital (figs. 99–102).

The hospital is located in the new buildings erected for the Pasteur College and was turned over to the American ambulance at the time of its organization, the latter part of August, 1914. The

buildings are arranged in the form of a square with a large central court, and although the general construction is not along the lines that would be selected for a hospital, it lends itself very well for the purpose for which it is used, namely, a temporary surgical base hospital. There are three large four-story buildings in the front, connected by large archways, the latter being used for housing automobiles and for the carpenter and general repair shop. The offices, committee rooms, and laboratory are located in the central building, the upper part of which is used for female-nurse quarters. The upper and front part of the right wing is occupied by the medical staff, while the wards and operating rooms, X-ray and other special rooms are located in the large four-story connecting buildings in the rear.

The institution is supported by voluntary subscriptions in America and is under the fostering care of the American Red Cross Society, which arranges for a certain number of doctors, representing various medical schools in America, coming over as a surgical unit, with a term of service of three months. The larger number of female trained nurses also come from America, although there are quite a number of French nurses employed here along with a large and variable number of *auxiliaire* nurses from America, France, and England. The hospital is controlled by a committee of Americans, resident in Paris, who follow the recommendations of the medical board, the latter being composed of all the heads of departments and visiting surgeons.

The work of this hospital is divided up between four surgical services and a surgical dental service. Dr. Winchester DuBuchet, an American surgeon resident in Paris, is the surgeon-in-chief, and is the head of one service. Dr. Joseph Blake, formerly of New York, is the head of another service, and another service is under the ranking surgeon of the university unit. The fourth surgical service has been a variable one in that it has been in charge of French Army surgeons, who have been changed at different times on account of certain conditions arising which have resulted in a change of detail. The very important and rapidly growing surgical dental service is under the joint control of two American resident dentists, Drs. Hayes and Davenport, who are assisted by six other dentists from America and England. Each of the surgical services works in conjunction with the dental surgical service and each has a separate ward for "jaw" cases. Each service also has a contagious ward, located on the top floor, for the isolation of any contagious case which may develop after arrival. There is also a nose and throat specialist and an eye and ear specialist, who have joint charge of any patients in the different wards who may happen to need their services. The house officers and internes are all men of hospital training from

America, who volunteer their services for a definite time, and who are replaced by the heads of the different services as vacancies occur.

Upon arrival at the hospital each patient is examined by the house officer of whichever service happens to be receiving. As the patients are invariably in a very dirty condition from prolonged work in the trenches, they are thoroughly bathed before being assigned to a ward (fig. 103). The dressings are then adjusted and the patients prepared for whatever surgical procedure is necessary. At this time the wound tag is carefully examined to ascertain the character of the injury and also to determine whether the patient has received an injection of antitetanic serum. If there is any doubt as to whether the patient has received the serum he is immediately given an injection. There is no doubt as to the efficacy of this serum, as no cases of tetanus have occurred throughout the entire army since the institution of the prophylactic injections the early part of the present year. Patients arriving in the forenoon are usually operated upon in the afternoon of the same day, and those arriving in the afternoon or night are operated upon the next morning, unless the indications are for immediate intervention.

By far the largest percentage of cases treated in this and other surgical base hospitals are compound fractures involving long bones, and mutilating wounds of the face. The reason for these wounds predominating in a base hospital is because they not only represent a class of cases which require complicated surgical interference, but also the cases which, after the first dressing, will usually bear transportation to the distant rear. Certain other serious wounds, such as penetrating or perforating wounds of the abdomen or skull, or injury to blood vessels or a vital organ, are chosen for such immediate interference at one of the fixed field hospitals as the case demands. The vast majority of these cases would die if not treated at once, and for this reason they do not usually reach a base hospital until they are convalescent, and hence able to be moved to the rear.

It is true that a certain small percentage of head cases, such as foreign body or depressed fracture, eventually come under the care of a base hospital, but they represent a class of cases which, in the judgment of the field surgeon, had best be treated by a specialist at a base hospital, particularly if the patient's general condition will stand transportation. Penetrating and perforating wounds of the chest reach a base hospital at comparatively rare intervals and are usually empyemas, or abscesses resulting from the presence of a foreign body. It is in these latter cases that the magnet, to be described later (p. 106), can ofttimes be used with great satisfaction in removing a piece of shell from the chest.

The treatment of compound fractures of the extremities differed somewhat on each surgical service as regards the general arrange-

ment for securing fixation of the fragments. For the fractured femurs on Dr. Blake's service the Blake splint was used, which not only held the bones in place satisfactorily and was comfortable to the patient, but admitted usually of dressing the patient without difficulty. In applying this split (fig. 108) after the necessary operation has been performed and the wound dressed, the limb is elevated and held in extension while the splint is placed under the limb, with the curved upper part of the splint (5) against the gluteal muscles. The limb is then lowered and specially made extension straps (to be described later) are glued to the leg and then the ends of the extension straps secured tightly to the buckles (4) attached to the metal foot piece. With the limb securely extended in the splint, wide supporting straps (not shown in photograph) are arranged under the limb (two for the thigh, above and below the wound, and two for the leg) so as to support the entire limb in the splint. The two permanent straps (1 and 2) are then buckled snugly over the limb and hold the latter securely in the splint.

The splint is made entirely of metal and practically in two pieces. The wrought-iron bar is one piece, and is bent as indicated (5) in the photograph. The upper part of the splint (5), which rests against the gluteal muscles, is well padded and covered with smooth rubber sheeting. The metal foot piece is 3 inches wide, with slits for the permanent buckles (4), and on each side is a round hole to allow the two ends of the bar to pass through easily. The metal foot piece is turned up on its lateral aspects and a set screw (3) on each side secures it at any desired point along the bar. The upper part of the splint (5) can be easily widened to suit a large thigh, or padded when the thigh is small. The splint is about 11 inches wide at the top and 4 inches between the bars at the bottom. After the patient has been removed to his bed the splint is suspended, as indicated in figure 106, and the entire splint is continuously pulled toward the foot of the bed by a cord and weight (about 10 pounds) attached to the metal foot piece after the manner of a Buck's extension. After a limb has been put up in this manner for some time the foot has a tendency to drop, so that it is necessary to secure it to an upright foot piece of simple design, as indicated in above figure.

As regards the operation for the general run of compound fractures of the femur, as well as all other compound fractures, dependence was placed on thorough drainage above, below, and to the side if necessary. Only unattached pieces of bone and foreign bodies were removed. As neither wiring nor plating could be done in the presence of infection, the bones were placed in as good position as could be obtained by extension and then secured in the Blake splint. In case of faulty or fibrous union, a plating or wiring operation, after healing has taken place, is indicated. In some instances fixation of

the fragments was secured by grooving out a V-shape portion of the end of each fragment and then crossing the V's, thus locking the bones together (figs. 109 and 110).

The after-treatment of these cases consisted of daily irrigations with a mild antiseptic and then the wounds put up in moist dressings until the infection subsided. A number of antiseptics were tried on a large number of cases, such as a weak aqueous iodin solution, an aqueous solution of sodium hypochlorite, 1 to 2,000 permanganate of potash solution, 2 per cent silver nitrate solution, and a 10 per cent solution of a patented creosote compound. The silver nitrate acted well in the presence of large infected sloughs. The sodium hypochlorite solution and the creosote compound were, generally speaking, satisfactory, especially with the cases which showed a tendency to gas formation. The drainage in every case, however, is by far the most important factor and should be kept free and unclogged. The Dakin antiseptic fluid has not been tried out at this hospital up to the present time, as the correct formula has only been recently published. Several of the surgical services have expressed the intention of giving it a thorough trial, and it is believed that the general results will be an improvement over the other antiseptics as used at present.

Cases of infected compound fractures are very difficult to treat under any circumstances, as there are always from two to three openings for drainage. The Blake splint usually meets the requirements in a very satisfactory manner and the general results are excellent. Of course there are some cases of shattered femur for which no line of treatment so far has proved satisfactory, and they represent a class of cases for which the best that can be hoped is to control the infection and let the merits of the case determine afterwards the special line of treatment to be pursued. Such cases as infected compound or comminuted fractures involving the upper femur and the pelvic bones are in this category (fig. 114).

Another method of treating infected compound fractures of the femur (Dr. DuBuchet's service) was to use a modified Blake splint, so bent and supported as to secure an inclined-plane effect, the leg being supported in a movable cradle, as indicated in figure 112.

The method which seemed to be preferred by the Harvard University unit in the treatment of fractures of the lower extremity was putting up the cases in an interrupted plaster cast, the wound opening being bridged over with heavy pieces of wire netting reinforced by plaster (fig. 113). The University of Pennsylvania unit, which succeeded to the service of the Harvard unit, used extension splints with lateral fixation. On Dr. Blake's service the Steinmann pins were used several times for multiple simple fractures of the femur with very fair results (fig. 115).

Compound fractures of the leg, sometimes involving either the knee, ankle-joint, or foot, are of rather frequent occurrence in a base hospital. They represent a class of cases which, as a rule, are not as difficult to treat as compound fractures of the femur. For knee-joint involvement free drainage, daily irrigations, and the Blake splint gave excellent results, although involvement of the knee-joint always means various degrees of restricted motion as an end result.

As a general rule some form of lateral fixation, with support of the leg in suspension, was used for infected compound fractures of the bones of the leg. As in the case of femurs, these fractures require daily dressing and the fixation apparatus has to be suited to the special needs of the case. A form of sliding cradle, as shown in figure 111, was used with great satisfaction in connection with extension on the leg by a weight secured to a cloth anklet (a pattern of the anklet is shown later). This cradle admits of loosening up any part of its under support in order to permit the dressing of the wound without movement of the fragments.

Compound fractures of the lower third of the leg, which usually involve the ankle-joint and foot, are specially difficult cases to treat, as the anklet, to which the extension is secured, has to be removed at each dressing. These cases, though long drawn out, did well in either the cradle or modified Blake splint (fig. 116).

The application of overhead extension to the treatment of infected compound fractures of the humerus, particularly those involving the shoulder or elbow-joint, was thoroughly tried out on Dr. Blake's service with great satisfaction to both patient and surgeon. Like other infected compound fractures of long bones, the through and through drainage wounds have to be dressed frequently, and this method was devised to obviate the removal of the limb from a splint at each dressing. This latter procedure always results in disturbing the fragments and consequently giving rise to faulty results, besides retarding the healing process.

The apparatus for applying this method of treatment is shown in figures 117–121. As will be seen a simple wooden frame is secured to the patient's bed to which the pulleys are attached. Wide cloth (canton-flannel) straps, with webbing extensions, are glued directly to the skin from the elbow to the wrist. These straps are the same, only smaller, as those used in connection with the extension on the Blake splint. A more detailed description of the application of these and other straps, together with the formula for the glue, will be given later (p. 98).

The straps are used to take the place of adhesive plaster on the principle of the Buck's extension. It is remarkable how soon all pain and swelling leave the arm with the use of this method. The fever and infection also quickly subside. As for the weights, when

the arm is to be fully extended, just enough weight is used to ensure the arm in this position.

When double extension is used (figs. 117–121) about 5 pounds is generally necessary for the upper weight, and between 7 and 10 pounds for the lower. As already indicated, the arm is kept in complete extension for 12 to 14 days. This not only gives time for the infection to clear up, but allows for a certain amount of fixation of the fragments by fibrous union. The elbow is then slowly bent to a right angle, usually taking from two to three days, and the direct extension is then applied. This latter is kept up for about three weeks, and then the arm is put up in molded plaster or light lateral splints.

During the entire management of the case by the overhead extension method the patient is perfectly comfortable and the wounds can be satisfactorily dressed without disturbing the position of the fragments. As already pointed out, this latter consideration is highly important, as it not only prevents faulty union and shortens the healing process, but it seems to have a decided influence in lessening the amount of callus that is thrown out around the fragments, thereby diminishing the chances of nerve involvement.

Another advantage of the overhead-extension method is that it gradually allows a certain amount of movement to take place in the elbow and shoulder-joint, which greatly aids in obtaining functional use of these joints after union of the fragments has occurred. It is believed that by this method there is less muscular atrophy, and that the soft parts will be more quickly restored to normal by the usual massage which has to be instituted in every case of fracture after the limb has been removed from the splint.

The surgical procedures outlined for compound fractures of the femur and leg are the same in principle, in regard to operative technic, as for compound fractures of the humerus (figs. 122, 123, and 126). In both of these cases, which are usually due to shell or shrapnel, it is of the utmost importance to remove the foreign bodies, especially small bits of clothing, which are carried into the wound by the fragmented projectile. If this is not accomplished at the time of operation, prolonged suppuration, faulty union, and a tardy convalescence will surely occur. Not only are all shell and shrapnel wounds infected but the great majority of bullet wounds affecting bones, and consequently explosive in character, are also infected. In shell wounds there is nearly always considerable loss and masceration of tissue which invariably causes a certain amount of sloughing to take place during the period of after-treatment. A shrapnel ball causes usually a large round wound of entrance with an area of ecchymosis and contusion surrounding it (fig. 124). Although shrap-

nel balls are prone to lodge in the tissues, they are frequently deformed and not infrequently fragmented.

The rifle-ball wound usually shows a small round wound of entrance with an apparent scorching or charring of the skin and superficial tissues surrounding the opening and channel (fig. 125). For this reason it is good practice to excise the devitalized skin around the small opening at the time of operation, as it will be sure to slough later.

In rifle-ball, shrapnel, and shell wounds which demand operation, the incisions should be complete enough not only to allow for liberal drainage but to admit of the removal of all foreign material. In shell wounds the ragged tissue, especially fascia, must always be removed along with unattached bone and foreign bodies. Shrapnel wounds resulting in the destruction of deep tissues are to be similarly treated. If possible, an X-ray plate of the affected part should be obtained before operation. This, however, is not always practicable, as sometimes a large number of wounded will arrive together and some of these may demand immediate attention, so that delay for an X-ray plate is not always justifiable. Fenestrated rubber tubing is in more or less general use for insuring drainage, although rubber tissue is a valuable substitute, specially during the course of the after-treatment. Irrigations must be employed, as already indicated, to remove the secretions at the time of the daily dressings, while wet antiseptic dressings are necessary in case of virulent and sloughing infections.

Compound fractures of the forearm caused by projectiles usually result in great destruction of bone (figs. 127 and 128). The latter is to be replaced by autogenous bone graft whenever practicable, and the principles of surgical treatment are the same as outlined above for other fractures. Hand and foot wounds are by no means rare, although they are usually secondary to wounds of the forearm or elsewhere and are not infrequently due to grenade fragments.

Hand-grenade wounds are nearly always multiple and usually show considerable mutilation of the soft parts (fig. 129). They not infrequently give rise to compound fractures very much like the explosive shell, only smaller. The treatment is the same as for shell fractures, with additional procedures along general surgical lines for the multiple wounds.

The general surgical treatment of all wounds in the American ambulance was characterized by conservatism (fig. 130). No parts were removed at operation unless so mutilated that no possible use could be made of them. Amputation was a rare occurrrence, although it had to be resorted to at times in order to save life. Every effort was made to give the patient at least a useful part of an injured member. This required a great deal of care and labor in the

general after-treatment, but the results obtained certainly warranted it, and it is safe to say that the work of this hospital along the lines of conserving limbs has been well above the average even for peace times.

As regards the efforts at conservative surgery as practiced in this and other hospitals, the question has recently arisen as to whether or not, in certain thigh and leg cases, it is for the best interest of the patient always to strive to save the limb regardless of what may be the end result. Quite a number of cases are received at base hospitals which, on account of osteomyelitis or deep fascial infection, undergo prolonged suppuration; and this latter has been shown to give rise to grave anemias, amyloid and other degenerations, which, although the limb may be eventually saved, cause a very grave depression of the patient's vitality. In addition to this, a number of these cases which have survived prolonged infective processes will ultimately have to undergo several orthopedic and other surgical procedures in order to bring about a questionably useful limb.

The point for consideration is whether the best interest of the patient is always conserved by a prolonged effort to save a limb in the presence of an extensive and continuous infection rather than resort to amputation in these particular cases when it is apparent that the extensive infection does not clear up after a conscientious effort has been made to control the infective process. It is a matter of nice surgical judgment as to whether the patient will not be better off with an amputated limb and good general health in contrast to a procedure which may give a questionably useful limb and not infrequently a progressively depressed vitality, ultimately causing death from exhaustion or some intercurrent affection.

It is not contended that in all seriously infected compound fractures of the limbs amputation should be at once considered. The surgeon's problem is twofold, in that he has to weigh the benefits to be derived from a line of procedure which might result in at least a partially useful limb, and at the same time he has to consider the very important after-treatment feature of the case. The problem as a whole can not be dismissed lightly by either conservative or radical expressions of opinion. It is apparent that not only should every case be carefully considered on its own particular merits, but the advisability of departing from a preconceived idea, as regards certain conservative or radical principles of treatment, is also to be carefully weighed.

Undoubtedly a prolonged infective process gradually brings about a general local and constitutional condition which is detrimental in every way to the patient's welfare. On the other hand, if a patient can be tided over an infection which does not cause a marked general deterioration, it is certainly the part of wisdom to conserve the limb

with the idea of subsequent surgical procedures directed toward the correction of any existing deformity. In view of the fact that these patients are generally young men with a great deal of reserve strength, the surgeon can usually afford to adopt a middle course. At the time of operation the surgical procedures should be such as to anticipate a favorable clearing up of the infection. If, however, the infection continues, amputation should be kept in mind as a possibility, and its serious consideration should not be delayed until marked degenerative changes have already taken place in the patient.

As already indicated, the cases that reach this and other large base hospitals are usually from three to five days after being wounded. If an active and efficient sterilization of the wound could be universally instituted at an early period, say from 10 to 24 hours after being wounded, one important factor of the surgeon's problem would be usually solved, namely, doing away with prolonged infections. This point is being seriously considered by the French not only in the direction of perfecting their mobile field surgical ambulance units, but by establishing small base hospitals at convenient points which are near enough to the front to be reached by motor ambulance in a few hours at most. This would mean that these hospitals could be safely located from 10 to 12 miles behind the trenches and prepared to undertake any character of surgical work, including the thorough sterilization of all wounds.

In following out this idea it may be said to result practically in instituting an abortive treatment for infected wounds, which latter would mean practically all wounds in the present war. Dr. Alexis Carrel, who has made a special study of this phase of war surgery, outlines the following treatment in a personal communication to the writer with reference to handling all wounded:

1. *Early treatment.*—At the first-aid station, disinfection of the wound with tincture of iodin. If the wound is narrow, injection in the tract of a solution (Dakin) of hypochlorite of sodium. If the wound is large, dressing with gauze freely saturated with the hypochlorite. Do not use waterproofing on the dressing. This hasty disinfection is not necessary; nevertheless, it may considerably improve the prognosis of the wound.

The wounded should be transported as rapidly as possible, by motor ambulances, from the field dressing station to the hospital, where they can receive complete surgical attention. Only the wounded affected with serious hemorrhage or shock should be treated on the spot. Do away with transfers and useless delays in the ambulances and clearing hospitals. It is important to organize everything so that the wounded arrive at the ambulance within six hours following the wound. The future of the wounded depends upon the rapidity of transportation and the possibility of treating his wound as soon as possible. It is the same with wounds received in war as with appendicitis. When the operation is performed in the first 12 hours its results are nearly always excellent. No wounded should be sent to the hospitals in the interior before their wounds have been sterilized.

2. *Mechanical cleansing of the wound.*—Foreign bodies, projectiles, fragments of clothing, should be immediately removed. The finger, gloved with rubber and softly introduced into the wound, permits in many cases the extraction of foreign bodies. However, radiography and radioscopy are necessary. Openings sufficiently large to permit the exploration and cleansing of wounds should be made. As it is important not to traumatize the tissues, it is necessary to denounce the brutal maneuvers known under the name of sponging out, brushing, or cleaning out of wounds. The fragments of clothing, projectiles, and free bone splinters should be delicately removed with forceps or with the fingers. The hemostasis is accomplished as completely as possible. In infectious lesions, and particularly in fractures, it is necessary to determine the extent of the damage and to localize the diverticula of the wound.

3. *Chemical sterilization of the wound.*—An antiseptic acts only on the spot on which it is applied and if it is applied for a sufficient length of time. It is therefore useless to wash a wound with an antiseptic substance. On account of its short duration, a washing acts only in a mechanical manner. Consequently salt water suffices. Similarly, a very unstable antiseptic is of little value. That is why oxygenized water, which decomposes almost immediately upon contact with the tissues, has no practical value, although its germicide power may be high. An antiseptic substance should be employed which, acting in the presence of the proteid products of the serum and tissues, does not decompose too rapidly, and it should be spread over the whole surface of the wound, being renewed in such manner that its action continues during a long period. None of the antiseptic substances employed till now can be utilized, because these substaces are too weakly antiseptic or too irritating for the tissues. Amongst the new antiseptics the hypochlorite of soda prepared by M. Dakin is not irritating and its germicide power is high. The Eau de Javelle should not be employed, of which the amount of hypochlorite is very inconstant and which contains free chlorin and free alkali. Any ambulance pharmacist can prepare hypochlorites according to the Dakin method. A solution of 0.5 per cent is used. This solution is strongly antiseptic, and yet it can be employed on the skin and on the tissues for several days, and even for several weeks, without irritating them. It should not be employed at the same time with alcohol. One liter per day per wounded is sufficient. The solution is injected in the tubes with an ordinary syringe or with a syringe having a Gentile pear-shaped rubber tip. In hospitals there is used with advantage a count-drop apparatus analogous to that employed for the rectal instillation.

The liquid is employed in such a manner that it penetrates into all the diverticula of the wound and there renews itself constantly. Since the hypochlorite dissolves the necrotic organic matters and destroys them on contact, it should be instilled in an almost continuous manner. This can be effected in the following manner: Have prepared rubber tubes of 6 mm. in diameter, pierced with one or two holes at one of their extremities, and tubes of different lengths pierced with small holes and covered with sponge material. When the wound is narrow, or when a large wound presents narrow diverticula, the tubes covered with the sponge material are introduced into the tracts. In cases of fracture, the extremity of the tube should be in the middle of the fragments. If a liquid is injected into the tube, it saturates the sponge material instead of immediately being ejected, and thus remains in contact with the surface of the wound. In the case of surface wounds and large infectious wounds, the bare tubes are applied to the bottom of the wound or introduced into diverticula. Then the wound is filled with gauze. Before terminating the dressing, the liquid should be injected into the tubes and it should be ascertained that it penetrates to the whole surface of the wound. The dressing is completed by a

layer of nonabsorbent cotton through which pass the rubber tubes in which the antiseptic liquid is instilled.

The antiseptic substance should be constantly renewed. Every hour or two hours a sufficient quantity of liquid should be either injected into the tubes by means of a Gentile syringe or continuously instilled by a Murphy apparatus. The quantity of liquid to be injected is governed by the dimensions of the wound. It is necessary that the surface of the wound be well wetted and yet that the bed of the patient be not inundated.

4. Members affected with fracture or articular wound should be carefully immobilized. Recourse should be had as far as possible to plaster apparatus fitted with metal handles. The dressing should be daily examined and changed each time that it is necessary. It should be ascertained that the liquid penetrates into all parts of the wound.

GAS-BACILLUS INFECTION.

It has been rightly suggested that the term "gas gangrene" is a misnomer, in that it does not convey a scientifically correct etiological or pathological idea as regards the nature of this condition. As a substitute the term "gas infection" has been used by many as being more appropriate, since it expresses more accurately the general character of a process in which a number of factors have to be considered in order to arrive at a correct understanding of the condition.

The infection of wounds by gas-producing organisms is by no means a new condition. Attention has been repeatedly called to infections in previous wars which have resulted in an emphysematous condition of the tissues, while the anaerobic character of the organisms involved has been recognized for a number of years. In the present war the nature of the battle ground, the concentration of large numbers of individuals, and the underground methods of warfare have all combined to accentuate the presence of this infection and caused it to assume a prominent rôle in present-day military surgery.

The Welch bacillus has been long known as an anaerobic gas-producing organism, capable of infecting wounds, and causing more or less serious complications. Until the outbreak of the present war surgeons and bacteriologists have not had sufficient experience to justify a positive opinion as regards the etiological relationship of this and other gas-forming organisms in the production of what has been called "gas gangrene." The reason for this reservation has been the fact that numerous other organisms have been almost invariably recorded as accompanying an infection of this kind and also the fact that certain heretofore unidentified organisms, resembling the Welch bacillus, were seemingly also causative factors. In addition to this, chains of cocci organisms have been thought at times to have been able to assume a gas-producing rôle. The other organisms which have been found in gangrenous tissues and dis-

charges, where gas has been present, are the colon, proteus, and other putrefactive bacilli.

For several months after the war began the unidentified gas-producing bacillus, resembling the Welch bacillus, was known as the *Bacillus perfringens* on account of certain cultural peculiarities which seemingly could not be reconciled with the cultural characteristics of the Welch bacillus. However, as time went on and the bacteriological technic of war-hospital laboratories was more perfected it became more and more apparent to careful observers that the *perfringens* was really a strain of the Welch organism; and at the present time laboratory men of large experience are practically unanimous in pronouncing them identical. The first definite case in which the bacillus was isolated from the blood sufficiently early after death to completely establish its etiological rôle occurred at the American ambulance during the early part of the present year. At this time a culture of the heart's blood, three hours after death, gave a pure culture of *B. perfringens.* Since that time instances have multiplied in which the same organism has been isolated from the blood during life in seriously infected cases. Not infrequently a pure culture has been obtained from the wounds of undeniable clinical cases and the condition reproduced clinically in guinea-pigs after the tissues of the latter had been injured. Only after previous injury to the tissues of the guinea-pig could the progressive gangrenous condition be reproduced. At the Pasteur Institute it was said that an injury to the guinea-pig's muscle was sufficient trauma to cause reproduction of the process.

Etiology.—As regards the conditions which are favorable for gas-bacillus infection of wounds, it is to be noted that the *B. perfringens* has been found in the culture from many cases which present no clinical evidence of this form of specific infection. In fact, it is most unusual in base hospital work to examine the discharges from a wound and not be able to find the *perfringens* associated with either the staphylococcus, streptococcus, or other organism. Its practically universal presence in the discharges and tissues of all wounds of the present war which show any signs of infection would seem to indicate that the conditions for bringing about an infection with this organism are easily accomplished. That this organism flourishes in the soil and is to be found in every locality where the present trench warfare is conducted, leads to the belief that the primary source of infection is in the dirt from the trenches in which the combatants are forced to live for days. The organism has been many times demonstrated in the outer clothing of soldiers, so that it is easy to understand its presence in wounds where bits of clothing are to be found. The soldier invariably comes from the trenches or dugouts in a muddy or dusty condition, which latter is due to prolonged and

intimate contact with the soft and ofttimes rain-soaked earth. Under these circumstances, even when clothing is not present in the wound, it is an easy matter for the omnipresent *B. perfringens* to ultimately find its way into a skin opening.

The very fact that the organism finds such easy access to all wounds, and also apparently finds in the latter a suitable culture medium without always manifesting itself, suggests the necessary presence of other conditions, notably in the wound, before it begins to exhibit its virulency as regards specific gas infection. The pathology of the lesions which show clinical signs of this condition is generally of a uniform character. Invariably there is more or less pulpification of the tissues, associated usually with fracture of the bone, and there is evidence in every case of more or less circulatory disturbance. This latter may manifest itself by a frank blood-vessel injury, which of necessity would interfere with the nutrition of the part, or there may be evidence after some days of thrombosis, inflammatory swelling, and slight edema or skin mottling, any of which would indicate a certain degree of embarrassment to the nutrition of the part. There is some dispute as to whether the injury of a large blood vessel is one of the necessary factors for the development of a clinical case. Whether this be true or not, it would seem to be essential for the growth and progressive virulency of the organism that a certain amount of devitalized tissue be present in the wound. The organism unquestionably thrives best in the presence of necrotic material, whether this necrosis be due to a limited pulpification, with or without injury to a large blood vessel, or whether the subsequent sloughing be due to a secondary interference with the circulation.

A fatal case of gas-bacillus infection is one that has passed through the progressive steps of (1) *injury*, (2) *infection*, (3) *localized necrosis*, (4) *progressive gas production*, (5) *circulatory disturbance*, (6) *increased virulence*, and lastly *septicemia*. By timely and proper surgical measures the progress of the process may be arrested and eventually cured, or the open character of the wound may be originally such as to render the essential anaerobic growth of the organism a difficult matter. Thus it is that one may see various degrees of gas-bacillus infection, depending upon the character of the wound, the time and nature of the surgical interference, and the efficiency of the after-treatment.

Pathology.—Besides the extensive destruction and necrosis of the tissues immediately adjacent to the wound, there is marked parenchymatous degeneration of the muscles above and below the wound, and more or less marked edematous infiltration interspersed with gas bubbles of varying sizes. The toxins formed by the *B. perfringens* would seem to exert a special selective action on the planes of connective tissue, since it has been often noted at operation and at

autopsy that the necrosis has traveled with apparently greater rapidity along the fascial planes, which latter are often found to be much more extensively necrotic than the adjoining muscular tissue. The resistance of the tissues surrounding the wound is thus progressively lowered, and the subsequent necrosis increases the activity of the organisms, so that a vicious circle is rapidly established in which necrosis follows bacterial activity while the latter increases and becomes more virulent as a result of the necrosis. The outer walls of the blood vessels in the immediate neighborhood of the infective process are also apparently specifically acted upon by the toxins, and this very probably accounts for the extravasated blood so often seen beneath the skin or in the adjacent tissues, which in turn gives rise to the superficial mottling or discoloration.

Externally the appearance of a gas-bacillus infected limb depends on the stage and degree of infection. In the earlier stages nothing is usually apparent beyond the nature of the wound to indicate the gravity of the process. In from two to five days, however, in those cases in which the process is following the stages already indicated, there is apparently a certain though small degree of swelling; palpation will usually elicit the presence of gas in the tissues, as indicated by the crepitation, and there is also usually to be noted the loss of a certain degree of tissue elasticity almost resembling induration; a slowly progressive brownish or copper-colored mottling of the skin adjacent to the wound; a more or less characteristic and marked fetid odor, resembling somewhat the pungent, sweetish stench of dead fish; the discharge from the wound, unless there is a mixed infection, is usually of a thin sero-sanguineous character, which is not infrequently mud-colored; and lastly the more or less sudden appearance of crops of vesicles which vary in size from that of a pea to several inches in diameter (figs. 133 and 134). Although a pulse may be noted in one of the arteries distal to the wound during the earlier stages of the infection, it becomes progressively weaker as the process extends and in the last stage is always absent.

The fluid in the vesicles or blebs is of a sero-sanguineous character and not infrequently straw-colored. Rather rarely the fluid will show the presence of *B. perfringens*, but in most instances no bacillary infection will be found, although the staphylococci are not infrequently present. An examination of the deeper infiltrating serous fluid invariably shows the presence, rarely in pure culture, of the characteristic bacillus. In some of the fatal cases the infection rapidly travels up the limb and makes its emphysematous appearance in the tissues of the abdominal or chest wall. In certain cases involving the lower extremity the local tissue changes seemed to have been arrested at Poupart's ligament, although the blood was later found to be full of bacteria. In all fatal cases the heart and larger blood

Fig. 124.—Shrapnel-ball wound of thigh. (See page 72.)

Fig. 125.—Rifle-ball wound involving face, neck, and shoulder. (Courtesy of the Harvard unit. The arrow indicates the direction taken by the ball.) (See page 73.)

Fig. 126.—Infected compound and comminuted fracture of the entire upper third of the humerus, with involvement of the shoulder joint, successfully treated by the overhead extension method. (See page 72.)

Fig. 127.—Showing a large "explosive" wound of exit resulting from a rifle ball, causing the entire loss of the middle third of the ulna. (See page 73.)

Fig. 128.—Showing the bones of the forearm in the preceding case, after the operation for bridging over the bony gap in the ulna had been performed. In this case, after healing had taken place in the external wounds the scar tissue was removed and a piece of the patient's tibia was secured in the bony gap with chromic gut. The wound was then completely closed and the arm and forearm put up in plaster for five weeks. The result was complete functional use of the forearm. (See page 73.)

Fig. 129.—Hand-grenade wounds of the face and other parts of the body. (See page 73.)

Fig. 130.—Showing the hand of one patient and the foot of another. Two of many such general results which are given as an example of conservative effort. (See page 73.)

Fig. 131.—Showing secondary missile effect of a rifle ball striking binoculars, causing loss of right eye and multiple wounds of hand and face. The fragments shown were removed from eye ball, face, and hand.

Fig. 132.—Showing the multiple wounds from secondary missile effects of bullet passing through binoculars and lodging in eye ball, face, and right hand. Photograph taken several weeks after operation.

Fig. 133.—A fatal case of gas-bacillus infection in a perforating bullet wound of the right leg, resulting in a compound comminuted fracture of both bones, showing the characteristic discoloration, slight swelling, and typical cluster of blebs. Patient received six days after injury and an immediate amputation performed at middle third of thigh. There was no injury to the anterior tibial artery. (See page 80.)

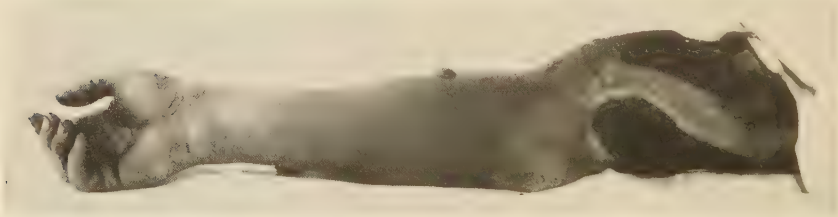


Fig. 134.—Fatal case of gas-bacillus infection of the arm and forearm, following a high-explosive shell wound of upper arm. Patient received five days after injury and an immediate amputation performed at shoulder joint. (See page 80.)

Fig. 135.—Showing a gas-bacillus infection of a mutilating shoulder wound, due to a high-explosive shell fragment, and accompanied by necrotic infiltration of a large part of the chest wall, which proved fatal. The patient was received five days after injury and the necrotic material was removed, followed by a continuous irrigation. (By courtesy of the Harvard unit.) (See page 82.)

vessels of the body and brain were found to contain large numbers of gas bubbles. Aside from the septicemic process, the presence of so much gas in the blood stream more than likely is the dominant factor in the sudden deaths to be noted in certain of the rapidly progressive fatal cases.

Under certain circumstances the infective process becomes circumscribed to a varying extent. When this occurs it is thought to be largely due to the invariable presence of a mixed infection, notably staphylococcus or *pyocyaneus* contamination. Aside from the surgical procedures which may have been instituted, it would seem that the occurrence at an early stage of these mixed infections may account for the protecting wall of leukocytes which forms and generally prevents an extension of the infective process. While tissue resistance undoubtedly plays a part in limiting or retarding the spread of this condition, the age and general vitality seem to have little, if any, influence in determining the outcome. The robust young patient, unless promptly and efficiently treated, falls as easy a victim as a less vigorous or older man.

Symptoms.—The signs of gas-bacillus infection depend upon the pathological stage of the invasion. The symptoms which characterize the successive *stages* have a direct relation, first, to the character of the wound, as regards size, situation, and degree of trauma; secondly, to the time elapsing between the reception of the injury and the institution of efficient surgical intervention; and thirdly, the care with which the after-treatment is conducted. Any one of these circumstances may not only have a decided influence on the progressive nature of the process, but are responsible in large measure for the intensity of the manifestations in the different *stages* and the virulence or activity of the infective organisms.

Gas-bacillus infection with the subsequent evolution of the respective *stages* is almost necessarily confined to wounds of the extremities, for the reason that the same degree of trauma and deep destruction of tissue, which always precedes a spreading infection of this nature, would almost invariably prove quickly fatal if applied to any other part of the body, such as the head, neck, chest, or abdomen. While mutilating wounds of the face and large or small superficial wounds elsewhere may show the presence of *B. perfringens* at one time or another, nevertheless the anaerobic and other general conditions for its favorable propagation or activity are usually lacking, and consequently there is very rarely any indication of an active invasion. For practically the same reasons wounds of the hands rarely give evidence of the specific gas-bacillus infection. Here the tissues are compact, but not thick, so that there is relatively very little depth to the wound, and as a consequence aerobic rather than anaerobic conditions

prevail. Deep wounds of the buttocks are specially prone to gas-bacillus infection, with next in order of preference the thigh, leg, arm, forearm, and foot (figs. 135 and 136).

Clinically, the first three *stages* of gas-bacillus infection, namely, *injury*, *infection*, and *localized necrosis*, are grouped together for the reason that they are so interrelated, as regards the invasion, as to form practically a distinct entity with reference to the onset of symptoms, and these three stages represent the first clinical *grade* of gas-bacillus infection. The reception of an injury sufficiently severe to predispose to gas-bacillus infection is always accompanied at first by more or less shock, the degree of which depends upon the damage to the tissues and the attendant loss of blood. Either the infective organisms are driven into the wound with pieces of clothing or dirt, or else they invariably enter the wound after a very short time, and thus find in a deep wound, the character of which has already been indicated, the suitable media and anaerobic conditions upon which they thrive. The invasion of the organisms does not immediately become manifest, so that the first indications of a constitutional involvement, after reaction from the shock, would be the sapremia due to the absorption of tissues but slightly removed from the normal, such as blood clot or serum. Within a few hours after *injury* the *localized necrosis* of the sides of the wound, though not apparent to the naked eye, would be present as the result of the severe traumatism inflicted upon the tissues in the path of the projectile. Although up to this point the specific activity of the gas bacillus can not be demonstrated, it may be stated with certainty that by the time the *localized necrosis* has become even microscopically manifest, the organism has begun its invasion.

The group of symptoms included under the general headings of shock, reaction from shock, and sapremia are what might be called the prodromal symptoms of the invasion. The slight febrile manifestations of the sapremia continue on into the slight fever which is due to the absorption of the newly formed toxins of the infective organisms. Thus, in from 10 to 30 hours after the *injury* the manifestations of the specific invasion are apparent. These manifestations are a fever of 1 or 2 degrees, accompanied by a rising pulse rate, slight headache, malaise, anorexia, and moderate thirst. If the part is splinted and protected, the patient does not complain of pain at this time. At this early *stage* there is no apparent enlargement of the wounded part, although a scant sero-sanguineous discharge is present, and if carefully examined will show the *B. perfringens*. The odor of the discharge at this time has begun to assume the characteristic fetid trait. Gas formation has also begun, although the characteristic "crackling" beneath the skin on palpation is rarely elicited at this time. Its presence in the tissues can be demon-

strated by opening up the pockets in the depth of the wound, which will cause perceptible escape of a certain amount of gas. Ofttimes in shaving the part at this time a slightly resonant note will be apparent, as if shaving over a tight membrane. A faint brownish discoloration will usually be seen in the skin immediately adjacent to the wound. The tension in the tissues of the limb would seem to be increased, in that there is a slight resistance imparted to the fingers during palpation. Some of these symptoms appear later than others; but as a rule within 48 hours, usually much less, all the manifestations indicated are present.

It is during this early part of the invasion that the abortive treatment already alluded to gives excellent results. Usually up to 24 hours the invasion and the tissue changes are not so far advanced but that vigorous methods of wound sterilization can be successfully carried out. After this time the changes are more pronounced, although up to 48 hours the condition has usually not progressed to such an extent as to give evidence of the more serious stages. From about 48 hours on, the more or less rapid progress of the infection is in direct proportion to the lapse of time.

The second *grade* of gas-bacillus infection is represented by the succeeding three *stages* already mentioned, namely, *progressive gas production*, *circulatory disturbance*, and *increased virulence*. These three *stages* are likewise grouped together on account of their clinical interrelation. This *grade* of the infection begins to appear usually after about 48 hours in the average run of untreated or inadequately treated cases. This *grade* extends usually from about 48 hours up to 4, 5, or 6 days, dependent upon the size and condition of the wound, the severity of the infection, the general resistance of the patient, and the character of any previous surgical treatment. If the condition has not been thoroughly treated during the first *grade*, the manifestations of the second *grade* make their appearance, as regards promptness and severity, in indirect proportion to the efficiency of the early surgical treatment. As the large base hospitals do not receive their patients until usually 4 or 5 days have elapsed since the wound was inflicted, it is nearly always the second or third *grade* of gas-bacillus infection which is treated in these institutions. Again, it is not unusual for a case to reach a base hospital after 4 or 5 days have elapsed, showing evidence of advanced second *grade* manifestations because of the fact that the onset of this *grade* has occurred during the more or less prolonged journey to the hospital.

Not a little confusion has arisen as regards the general description of what has been known as "gas gangrene." Some observers have described a condition which has been almost entirely unlike the experience of others. The reason that this occurs is due to the fact that different *grades* of the same condition have been described by differ-

ent writers and the general process was not considered as a whole. The experience of a surgeon whose work has been comparatively near the front and where he has only had to deal with the first *grade* is at variance with the experience of another surgeon whose observations in a base hospital farther to the rear deal entirely with the second or third *grade* of the infection. Hence it is that varying accounts of the same condition have appeared and given rise to doubt in the minds of many as to the exact nature of the process.

The onset of the second *grade* is usually characterized by a more or less pronounced increase in the pulse rate, which appears to be out of all proportion to the temperature. The latter is at first only slightly raised, but as the toxic products of the wound become more rapidly absorbed the temperature begins to mount, and may reach 104° or 105° F. in from 10 to 20 hours. The discharge from the wound is now frankly and characteristically fetid. If a mixed infection has occurred, which is usually the case, the thin serosanguineous discharge is augmented by the presence of pus. The progressive elaboration of gas, which has already begun, can now usually be detected by the crepitation or "crackling" in the tissues when the latter are palpated. The brownish mottling or discoloration of the skin near the wound is much more distinct than in the first *grade*, and shows a decided tendency to spread. The swelling of the part is now distinctly apparent, and the tissues in the neighborhood of the wound are slightly indurated, showing decided evidence of circulatory disturbance. Acute pain in the wound is now complained of, and it is not unusual for a severe pain to manifest itself in the lumbar region. The headache, anorexia, malaise, and restlessness are marked, and the facial expression assumes a dull stupid character. These symptoms are all of a progressive nature, lasting over a variable period of from one to three days, and this progressive feature of the symptoms indicates the *increased virulence* of the infective process. During this time, or possibly a few hours later, small successive crops of vesicles begin to appear on the skin adjacent to the wound, and may increase in size and number. When the symptoms of the second *grade* are well advanced, unless prompt measures are instituted, the patient begins to sink into a fitful coma-like condition which heralds the approach of the third and final *grade*, which is septicemia.

The insidious onset of the third or *septicemic grade* is characterized by a deepening of the stupor which has begun to make its appearance during the latter part of the second *grade*. There is now usually a rapid display of grave manifestations, which characterize an overwhelming infection and the invasion of the blood stream by the infective organism. The ominous sign of a falling temperature with a rising pulse rate makes its appearance. The apathetic stupor,

the shallow and jerky respirations, the loss of body temperature, the rapid and thready pulse, all bespeak the approaching end. Occasionally, in those cases that linger for a longer period, there is a typhoid-like manifestation which is characterized by a whispering delirium, the so-called "coma vigil," carphologia, a transient half-awakening or feeble restlessness, and a steady decline of both heart and respiration. In some cases death occurs within a very short period after the onset of the third *grade*. Sometimes within an hour the patient will rapidly sink and suddenly expire. This latter suggests the lethal presence of another overwhelming factor besides the septicemia. As already indicated, this may be attributed to the rapid liberation of a large amount of gas in the blood stream.

Diagnosis.—The diagnosis of gas-bacillus infection resolves itself into a recognition of the progressive nature of the process. In view of the fact that it is almost certain that every wound in the present trench warfare which shows the slightest sign of infection is contaminated by the presence of the gas bacillus, practically every open wound under the present conditions must be regarded from the very beginning as potentially a gas-bacillus infection. The one exception to this rule are those perforating bullet wounds which do so little tissue damage that they usually heal spontaneously. Even these wounds are not to be regarded too lightly, but must be treated expectantly for at least three days, as there is no immunity in any wound inflicted under the present war conditions. As already indicated, infection in some form is universal in every open wound of the present trench warfare, as statistics will show; and while the *B. perfringens* does not proclaim its presence in a certain percentage of these cases, nevertheless a careful bacteriological examination of the discharge is invariably positive. Under these circumstances a clinical diagnosis of the first *grade* of gas-bacillus infection can not be said to be demonstrable in every case of early infection that shows the latent presence of the gas bacillus. While the surgical treatment takes into consideration its more than probable future activity, yet a diagnosis of the first *grade* is tentatively withheld until there is evidence of the progressive manifestations already indicated.

It is true that other infections, which are improperly treated, show certain signs of progression, nevertheless the progressive nature of these infections presents a different picture from the indications of gas-bacillus infection. The latter infection is not only progressive at a much earlier period than any other known forms of wound infection, but its steady progress is characterized by an accentuation of certain features which are peculiar to gas-bacillus infection, namely, the localized necrosis, the almost characteristic odor and the slight skin discoloration. In addition to this, the thin sero-sanguineous discharge manifests itself within a few hours after active

gas-bacillus infection, in response to the activity of the organism and its toxin in the depth of the wound; while in the usual forms of other wound infections the characteristic discharge or pus is not evident for a much longer period. The rising pulse rate which is usually out of proportion to the degree of fever, while by no means pathognomonic of the first *grade* of gas-bacillus infection, nevertheless is highly suggestive in view of the usual febrile response to other wound infections in which the rapidity of the pulse is usually in direct proportion to the degree of fever.

The diagnosis of the second *grade* of gas-bacillus infection presents no real difficulties in view of the progressive nature of the process. Here the cardinal signs of beginning gas-bacillus infection, namely, the *necrosis*, *odor*, and *skin discoloration* are all accentuated. In addition there is the usual crepitation in the tissues as a result of the progressive gas formation; the swelling and slight local induration indicating *circulatory disturbance;* and the usual sharp rise of temperature, in connection with the increased pain and other minor symptoms, indicating an *increased virulence* of the infection. Since a mixed infection is usually present by the time the second *grade* is reached, a consideration of this complication, when present, shows a thick yellow or greenish pus, which later has a bluish tinge in case the contaminating organism is *B. pyocyaneus.* There is usually the further evidence of a more decided reaction in the tissues, as indicated by more or less edema. The behavior of the temperature would be somewhat different in that the rise would generally be gradual from the date of the mixed infection, instead of spasmodically high as is the usual result of an increased virulence on the part of the gas bacillus. In view of a sudden rise in the temperature, pneumonia or pleurisy must not be overlooked, and once thought of, can easily be confirmed or excluded.

As regards the diagnosis of the third *grade* of gas-bacillus infection, there is no essential difference between this *grade* and the septicemia caused by the presence of pyogenic cocci in the blood stream. It may be said that gas-bacillus septicemia appears to be somewhat more progressively asthenic in character than other forms and that it is apparently complicated at times by the presence of an excess of gas in the blood stream.

Prognosis.—The prognosis of gas-bacillus infection, like other factors considered in describing this condition, has to be regarded from the viewpoint of the progressive nature of the process. The three progressive *grades* of this condition present a progressively grave outlook as regards the conservation of tissues and the restoration of health. While the grouping of the progressive *stages* into three successive *grades* is a somewhat arbitrary, although decidedly convenient, division of the process, nevertheless it is also justified

and thoroughly warranted by the clinical behavior as a whole. Like other infectious processes, there is of necessity a continuity between the subdivisions which represent the individual clinical aspects of the condition, and by the same token it must be remembered that there is no sharp line of demarcation between the three *grades*. For this reason, in order to arrive at a correct understanding of the clinical outlook of the three *grades*, it will be necessary to consider the separate, though hyphenated, *stages* which constitute the process as a whole. In order to emphasize the clinical aspects of this condition and the grouping of the *stages* into *grades* attention is invited to the following tabulated arrangement, which shows the *grades* subdivided into the successive *stages*.

First grade.	Second grade.	Third grade.
1. Injury. 2. Infection. 3. Localized necrosis.	1. Progressive gas production. 2. Circulatory disturbance. 3. Increased virulence.	1. Septicemia

The first *stage*, that of *injury*, has a direct bearing on the future progress of the infection. If the wound is large, ragged, and deep it affords the ideal conditions for quick infection and rapid dissemination. The situation of the wound also influences the nature of the process. If the wound, by reason of its anatomical location, has injured one or more large blood vessels and nerves, the nutrition of the part is proportionately quickly embarrassed and the rapid death of the entire member may ensue. Under these circumstances the massive death of the tissues as a whole, known as gangrene and usually of the moist variety, is substituted for the classical progressive localized necrosis, which characterizes a purely gas-bacillus infection. On the other hand, if the wound, though deep and ragged, has not injured the important nutritive and trophic tissue elements, its subsequent relation to the infective process depends upon certain selective localities. As already indicated, the buttock seems to be more quickly and universally susceptible to gas-bacillus infection than other parts of the body. Next in importance would be the deep, narrow, and destructive wounds of the thigh. The same character of wounds in the leg would seem to follow as a selective sequence, while a destructive wound of the arm or forearm comes next in the order mentioned. Although certain other localities, already mentioned, have been known to exhibit signs of gas-bacillus invasion, yet on account of the thinness of the structures involved, it rarely manifests itself. The degree of traumatism as a prognostic factor is partially considered above, but on account of the known preference of the gas bacillus for pulpified and subsequently necrotic tissue, this factor,

as regards the rapid progress of the infection, is in direct proportion to the local devitalizing extent of the traumatic process.

The next feature of prognosis as regards the *injury* is the time elapsing between the reception of the injury and the institution of efficient surgical procedures. The longer the wounded remain without thorough surgical attention, the more certain will the infective process become firmly and progressively established. As Carrel has said, the general fate of the wounded is dependent upon the quickness with which they can be transported to hospitals where adequate attention is provided. The thoroughness of the surgical intervention is also a weighty factor in the progress of the infection. Haphazard and inadequate measures are responsible not only for a false sense of security in regard to controlling the progress of the infection, but also culpably involved in the serious and ofttimes fatal delay in the proper treatment of the wound, resulting from a lack of thorough surgical technic at a time when the process could be more certainly controlled. Once the thorough surgical measures have been instituted, the next factor, as regards the future welfare of the injury, is the care with which the after-treatment is conducted. Unless painstaking thoroughness characterize the after-treatment, not only is the process prolonged, thus subjecting the patient to the dangers which not infrequently arise from various complicating and devitalizing influences, but the ultimate result, as regards bone and other tissue healing, will be proportionately unsatisfactory.

The influence of the second *stage*, or stage of incipient *infection*, on the general prognosis of the process is likewise largely dependent on the promptness with which the wound can be thoroughly treated. The longer the delay the greater the opportunity for the infection to spread and become more virulent. Prompt and efficient measures at this time will largely limit and ofttimes abort the specific process and at the same time not infrequently prevent a mixed infection. As regards the latter, while it frequently occurs sooner or later under the usual conditions of war surgery, it always prolongs the general process and invariably vitiates the ultimate result. The longer it can be prevented the healthier the wound will become, and the consequent increased tissue resistance causes a more favorable outlook as regards throwing off any contaminating process and thus establishing a more satisfactory convalescence. While a mixed infection does appear indirectly to limit to some extent the spread of gas-bacillus infection by causing the usual protective wall of leukocytes to appear, nevertheless it is a condition to be avoided, not only for the reasons already given but because there are other and much better means of controlling the spread of the specific process.

The third *stage*, or *localized necrosis*, completes the first *grade* of the general process, for the reason that all the conditions are now ripe

for the specific organism to inaugurate its vicious circle and augment its virulency. The earlier the necrotic walls of the wound can be removed the speedier the cessation of the infective process. The amount of necrotic material in the wound necessarily exerts a potent influence, and the larger the amount of necrosis present the more radical must the procedures be in order to overcome the tenacity of the infection. The first *grade* of the general process presents on the whole a decidedly hopeful prognosis in the light of our present knowledge. The bacteriological and pathological conditions being known it is only necessary to put into practice the principles of treatment which are known to be effective in establishing as near as practicable a return to the normal. It is during this *grade*, before the organism has gained a firm foothold and increased its virulence, that the abortive treatment offers considerable hope of bringing about a rapid and uncomplicated convalescence.

The outlook for the second *grade* of the process is decidedly less hopeful in its general character than the first *grade*. The establishment of the second *grade* means that the gas bacillus, not unusually accompanied by a contaminating organism, is now more or less firmly implanted in the tissues of the wound and has begun in earnest the operation of its vicious circle. While somewhat dependent upon the degree of thoroughness in treating the infection during the first *grade*, the prognosis of the second *grade* depends largely upon the degree of progression in the three individual *stages* which make up the second *grade*. The first of these *stages*, which is *progressive gas production*, indicates that the principal clinical by-product of the infection, and the one which gives to the process its name, is being manufactured under circumstances progressively favorable to the progress of the process. The rapid evolution of the gas in the tissues predisposes the latter to a more rapid dissemination of the infection, in that it stretches the tissues and opens up new avenues for an extension of the process. It sometimes happens that the gas is so confined in the tissues, by reason of being pocketed, and the tension is so increased, as to cause a distinct explosive sound when the pocket is incised or the dressings removed, if the latter have acted as a plug in the wound. Hence it is, the more rapid the evolution of the gas the more rapid are the changes which follow closely upon this *stage*, and therefore the more unfavorable the outlook.

The second *stage* of this *grade*, namely *circulatory disturbance*, is an important factor in the prognosis in that its manifestations are usually apparent to the unaided eye, and thus afford a quick and reliable index as to the general condition of the underlying tissues. A *circulatory disturbance* means that the nutrition of the part is being hampered and that another link is being progressively forged which will increase the activity of the process. The indications of

this disturbance have already been mentioned. The parts in the neighborhood of the wound become distinctly swollen, and there is a slight indurated edematous condition apparent in the tissues adjacent to the wound. These manifestations indicate that the circulatory system is struggling to overcome the unsatisfactory nutrition of the part caused partly by the devitalizing influence of the increased amount of toxin in the tissues, and partly by the increased tissue tension due to the spread of the process. While the copper-colored mottling of the skin in the neighborhood of the wound is more or less apparent from the very first *grade* of the process, nevertheless this discoloration, being now influenced by the progressive *circulatory disturbance*, assumes a more decided brownish tint, which might be described as a brawny induration, and there is distinct evidence of its decided tendency to spread. This tendency of the discoloration to spread is in direct proportion to the extent of the *circulatory disturbance*, therefore the greater the disturbance the more extensive the discoloration. This brawny discoloration can usually be easily detected, and when its progressive character is manifest the gravity of the general prognosis is increased in proportion.

The third, or *increased virulence*, *stage* represents the climax of the second *grade* of the process. Its manifestations are closely associated with and dependent upon the preceding *stage* of *circulatory disturbance*. The progressive devitalization of the part, beginning with the localized necrosis in the walls of the wound, has now reached its culmination in the more extensive local death of the surrounding tissues. Once the resistance of these surrounding tissues is completely overcome, the rapid extension of the devitalization is assured and a fulminating character is imparted to the process. Besides the clinical evidence already mentioned, the *increased virulence* of the infective process is evident from the suddenly more extensive activity of the process and its rapid dissemination throughout the dying tissues. Hence it is that the massive death, which is now progressively occurring in the tissues surrounding the wound, has received the name of "gas gangrene." The most potent and continuous influence in causing this gangrenous process is undoubtedly the toxin elaborated by the infective organism. This toxin is the pivot in the vicious circle by means of which necrosis follows the elaboration of the toxin and bacterial activity is increased by the necrosis. The production of gas is only an incidental by-product in the process, and hence the term "gas infection" should also be discarded, in that it does not express the true nature of the process. In view of the progressive character of the infection and its ability to create the conditions favorable for continuance of the process, the term "progressive emphysematous necrosis" would more accurately express the

character of the condition and at the same time indicate its most prominent clinical manifestations.

The prognosis of the third, or *septicemic*, *grade* of the process is exceedingly grave. It represents such an overwhelming degree of infection that all protective barriers have been swept away and the systemic invasion by the organism has occurred. As in other septicemias, this lethal process is progressively asthenic in character, but it would seem to be specially so in this particular form, which would also seem to indicate a total breaking down of all resisting power. Under these circumstances it is not surprising that sudden deaths occur which may be hastened by the embarrassing presence of an unusually large amount of gas in the blood stream.

Treatment.—The line of treatment to be adopted for this condition is to be considered under three distinct headings, according to the indications, which are usually apparent, as regards the invasion by any infective process. Thus there would be the prophylactic, the abortive, and the curative procedures.

The prophylactic procedures would seem to resolve themselves into the precautions which are more or less familiar to all, and which are the usual precautions against wound infection. Under the present circumstances of the trench warfare in Europe it would seem to be well-nigh impossible to obviate an exceedingly high percentage of wound infection, and especially infection with the organism responsible for the *progressive emphysematous necrosis*. The reasons for this are not far to find. In the first place the entire western European war area has undergone for many years an intensive process of cultivation which has resulted in the soil being saturated with fertilizers and caused it to be the medium par excellence for harboring the infective organism. Once the trenches are dug deep in this soil, there is no escape from the ever-present conditions which are favorable for infecting every wound. Soldiers are obliged to occupy these trenches for days and nights consecutively under all weather conditions, so that their clothing and body surface become more or less permeated with the trench dust and dirt, which of course contains the infective organism in great numbers (fig. 138).

A consideration of these facts leads to the theoretical conclusion that something might be accomplished in a prophylactic way by not only covering the floor of the trench with small fagots of wood, which is now the universal custom, but by making an effort at the disinfection of the sides of the trench. Calcium hydrate, or slaked lime, white-washed thickly and repeatedly along the sides of the trench could at least do no harm and doubtless would be productive of not a little indirect good. Besides being very cheap and easy to acquire in large quantities, it is a deodorant and possesses distinct antiseptic properties.

The sides of the trenches are frequently lined by upright stakes interlaced with cross-pieces of thin wood in order to prevent the crumbling dirt from falling into the trenches. This arrangement would be more favorable for the application of the white-wash than when the sides of the trench are unprotected, although under the latter circumstances, once the dirt is hard and dry, it would be no great difficulty to keep a thick coating of lime on the trench walls. There could be no military objection to this, as it would not be visible to the enemy under ordinary circumstances. Small sections of the trenches are covered over to some extent all along the line, and the positions of the opposing trenches are perfectly familiar to all combatants in the field, so that any added feature of trench hygiene, even though conspicuous, would not unduly expose the occupants to the enemy's fire or cause the enemy's attention to be attracted any more than at present prevails. Cementing the wall of the trench has been done in selective places, but as anything like a general application is out of the question for many reasons.

There is something to be said about the clothing from a prophylactic standpoint. The French soldier's uniform and overcoat, which latter he wears continuously for some reason both winter and summer, is made out of a thick, coarse, felty material which certainly becomes very easily more or less permanently contaminated with dirt. Body-sweat and rain keep the clothing inundated for considerable periods, and this moisture in the fabric helps to maintain the vitality of any organisms which may be present in the dirt. The British soldier's uniform is composed of somewhat the same character of material, resembling a rather thick flannel. It would certainly be the part of wisdom, from the viewpoint of infection, to adopt a less porous and more easily cleansible type of uniform, such as a khaki cloth which has a hard finish. In addition to the foregoing, cleanly habits and a rigorous policing of all trenches would, of course, be productive of general good.

The soldier should receive as a necessary part of military training repeated instructions in the rudiments of asepsis, antisepsis, and the conditions favorable to wound infection. This would unquestionably not only lead to a more careful and intelligent application of the first-aid package, but would be conducive to far-reaching good as regards improving and avoiding the conditions favorable to infection. At the first-aid stations iodin should be freely used, pouring it into the wound and applying it to the surrounding surface. Carrel recommends the injection of Dakin's fluid into narrow wounds at this time, and also dressing the large wounds with gauze saturated with the same solution.

The abortive treatment of this progressive infection contemplates being able to thoroughly treat the wound within 12 hours after the

receipt of the injury. The earlier this treatment is begun the better the outlook for accomplishing its purpose. The principles of this abortive treatment are twofold—mechanical and chemical. The mechanical process calls for the prompt and delicate removal of all foreign bodies, such as projectiles, fragments of clothing, and unattached splinters of bone. It is necessary, in the vast majority of cases, to enlarge the wound in order to thoroughly accomplish this important feature of the work. The X-ray is a valuable adjunct and should always be used when practicable. There should be as little traumatizing of the wound as is consistent with thorough surgical technic. All overhanging and ragged edges should be carefully trimmed and the wound should be thoroughly inspected to ascertain the presence of loose, ragged, or apparently devitalized tissue. Pieces of fascia should be carefully removed and the sides of the wound left as smooth as possible. All bleeding should be thoroughly controlled at this time and the general extent of the damage ascertained.

The chemical part of the abortive treatment calls for the continuous application of an antiseptic which will not only promptly destroy the organisms with which it comes in contact, but which will dissolve or detach any pieces or areas of devitalized or necrotic tissue which happen to be left behind or develop afterward in the wound. The Dakin fluid is such an antiseptic, and is not only highly germicidal but is practically nonirritative. As regards large wounds, the thorough application of this fluid is accomplished first by the introduction into the depth of the wound of long fenestrated narrow rubber tubes, the number depending on the size of the wound and the diverticula present. The object is to so place the tube or tubes that when fluid is injected through them and into the wound it will reach all parts. With the tubes in place, and projecting for 4 or 5 inches outside the wound, the latter is now lightly packed with gauze saturated with the Dakin fluid. Alcohol should not be used in conjunction with the Dakin fluid, as it causes the latter antiseptic to become very irritable to the tissues by the rapid liberation of free chlorin. A layer of nonabsorbent cotton, through which pass the rubber tubes, completes the dressing. The fluid is injected every one or two hours into the tubes, or the latter may be coupled to a Murphy drip apparatus. The object is to keep the gauze in the wound thoroughly saturated with the fluid, but not cause it to leak from the wound. This is kept up for sometimes as long as 48 hours, depending upon the size and character of the wound. At the end of this time, if the treatment has been thoroughly carried out, the wound will be sterilized in the great majority of cases. The wound is inspected and the dressings carefully renewed every morning.

In addition to the sterilization of the wound the abortive treatment also contemplates the use of some form of permanent dressing

or an apparatus best suited to the special needs of the individual case. In case of a fractured bone the use of a carefully applied plaster dressing, either in the form of a fenestrated permanent cast or as a molded splint, is recommended. Plaster is advocated for the reason that, as soon as the sterilization of the wound is assured, the patient can be evacuated to the rear much more easily and safely in this form of splint than in others. When the large base hospital of the interior is reached the cast may be removed if thought necessary, and any form of special apparatus applied that will best suit the individual needs of the case. As regards the patient's transfer to another hospital, no case should be transported, except in an emergency, until the sterilization of the wound is complete. It has often occurred that the delay incident to prolonged travel has resulted disastrously for the patient when there is an active infection in the wound.

It has been the practice with a large number of surgeons as regards the early general treatment of wounds to open up the latter thoroughly, remove foreign bodies, irrigate with salt solution or an antiseptic, introduce drainage tubes, and either use a dry or wet dressing, according to the individual preference of the surgeon. Whether or not the surgical indications have always been conscientiously carried out, it is a fact that a very large number of wounds reach the base hospitals of the interior in a septic condition. This indicates that the early and subsequent treatments have not been thorough enough to prevent a continuance of the infection. The abortive treatment outlined above has been successfully used a large number of times, and there is every reason to believe that, when conscientiously applied, it will greatly improve the statistics of wound infection. It must not be lost sight of that in the abortive or any other line of treatment one of the cardinal surgical indications is to produce aerobic conditions in the wound instead of anaerobic, which latter is the condition most suitable for a continuance of the infective process.

The curative treatment has specially to do with the second *grade* of the infective process, and it is this *grade* of the condition that has usually been treated in the large base hospitals of the interior for the reasons already given. This form of treatment either calls for a continuation of the treatment already instituted elsewhere or the adoption of special procedures to meet any special demands. In the beginning this treatment may be an intensified continuation of the abortive treatment outlined above or it may take the form of any special surgical procedure individually preferred by the surgeon. The X-ray should always be made use of as a matter of routine to ascertain if any metal has escaped being removed in the previous treatment. It is usually a foreign body, either metal, cloth, or bone,

which is responsible for keeping up the infection in the earlier *stages* of the second *grade*. In any case the wound should be thoroughly inspected and all pockets or diverticula opened up. Any necrotic material should be carefully trimmed away at this time, and specially should necrotic or loose fascia be sought for. As this class of cases usually presents a mixed infection, it is more than likely that drainage tubes will have to be used to facilitate the drainage of pus. These tubes need not interfere with the use of the Dakin fluid as outlined above. Some operators may prefer to adopt a different line of treatment than the Carrel method, in which case it may take the form of any well-recognized surgical procedure. Dr. Wineberg, of the Pasteur Institute, has introduced a serum which has been tried in a large number of cases, but so far no decided results have followed its use.

After the case has been operated upon, the general and local condition must be carefully watched. If the infection is being controlled and improvement sets in, the temperature and pulse subside, the discharge becomes progressively less, the wound gradually assumes a healthy appearance, and a satisfactory convalescence is established. If, on the other hand, the condition not only does not improve but shows indications of becoming progressively worse, certain radical measures must be contemplated, with the idea of at least saving the patient's life. In case the process involves the upper or lower extremity, amputation may be performed as a life-saving measure. This must not be undertaken too lightly, nor must it be so long delayed as not to reasonably insure saving the patient.

Sir Almroth Wright has recommended the placing of strips of gauze into the depth of the wound and into special incisions which are made with a view of reaching the deep fascial planes. These strips of gauze are kept more or less continuously saturated with salt solution, and the presence of the latter in the wound causes a certain amount of responsive outpouring of serum from the tissues. This treatment has been used with apparent success by a number of British surgeons and at the Japanese Red Cross Hospital. While this method of treatment may be satisfactorily used in selective cases, it is the opinion of quite a large number of surgeons, who have had considerable experience during the present war, that the great majority of progressive cases require a more radical treatment, such as not only a thorough opening up of the wound, but also the more or less continuous use of an active antiseptic.

Another method of treatment, which was enthusiastically indorsed by a few, consisted in the subcutaneous introduction of oxygen under pressure into the tissues above the wound. This method was reported as being in successful operation at a certain few hospitals, but it has been thoroughly tried out a number of times in other hospitals, and

the reports have been almost invariably to the effect that the procedure exerted very little influence, if any, upon the infective process.

The indications for amputation are largely a matter of surgical judgment and experience. A number of factors would have to be considered before arriving at a definite conclusion as regards the entire removal of a limb. It is during the latter part of the second *grade* of the progressive process, namely during the *stages* of *circulatory disturbance* and *increased virulence*, that amputation comes up for serious consideration. It is because of the rapid local and constitutional changes at this period that the surgeon must be on his guard and prepared to act promptly in case a decision is reached. Familiarity with the pathology of the last two *stages* of the second *grade* of the process will alone enable the surgeon to form an intelligent opinion as regards the radical removal of the offending member. Consideration must be given not only to the local tissue changes as manifested in the *stage* of *circulatory disturbance*, but the constitutional resistance must be carefully estimated at the *stage* of *increased virulence*. As already indicated, these two last *stages* of the second *grade* are so closely interrelated and the process as a whole is so dependent upon the mutual and responsive reactions occurring between these two *stages* at this time that the climax or crisis represents the culmination of the more or less rapid general changes which have taken place as the result of this intimate relationship between the two stages. The index of the critical point in the patient's condition is therefore the point where the local and constitutional manifestations have converged to form a picture of combined and acute distress.

Under these circumstances the local manifestations which would call for removing the part would be the more or less rapid display of progressive tissue death, as indicated by the spreading discoloration, the increased edematous induration, and the manifest inability of the embarrassed circulation to reestablish itself in the swollen and tense member. At this time there would be a perceptible loss of temperature in the tissues below the wound and no appreciable evidence of a distal pulse or circulation.

The serious constitutional manifestations, which follow closely the above local changes and which indicate an *increased virulence*, are those which show unmistakable evidence that the infective process is gaining a more or less rapid ascendency over the body resistance. The temperature at first would begin its spasmodic or steady rise, the already disproportionately rapid pulse would further increase in rate, and the patient would exhibit the dull and listless attitude toward his environment which shows the influence of a powerful depression.

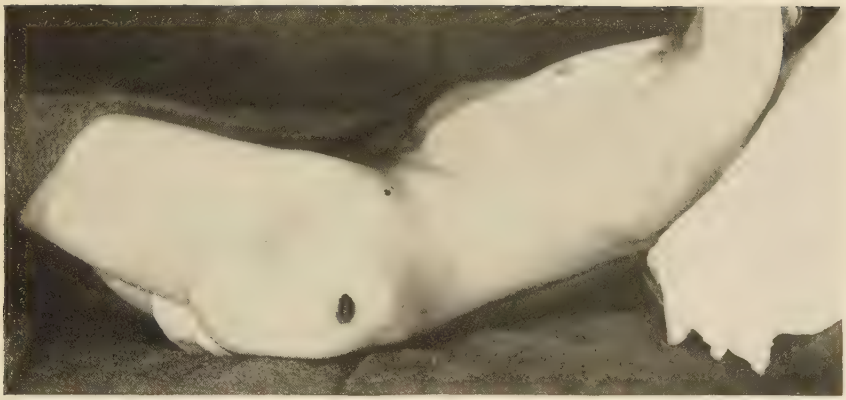


Fig. 136.—A case of first-grade gas-bacillus infection, the result of a bullet wound involving a slight splintering of the iliac crest. Patient was received three days after injury, the onset being less rapidly progressive than the usual ragged shell wounds. Note the slight brownish discoloration in the skin adjacent to the wound. (See page 82.)

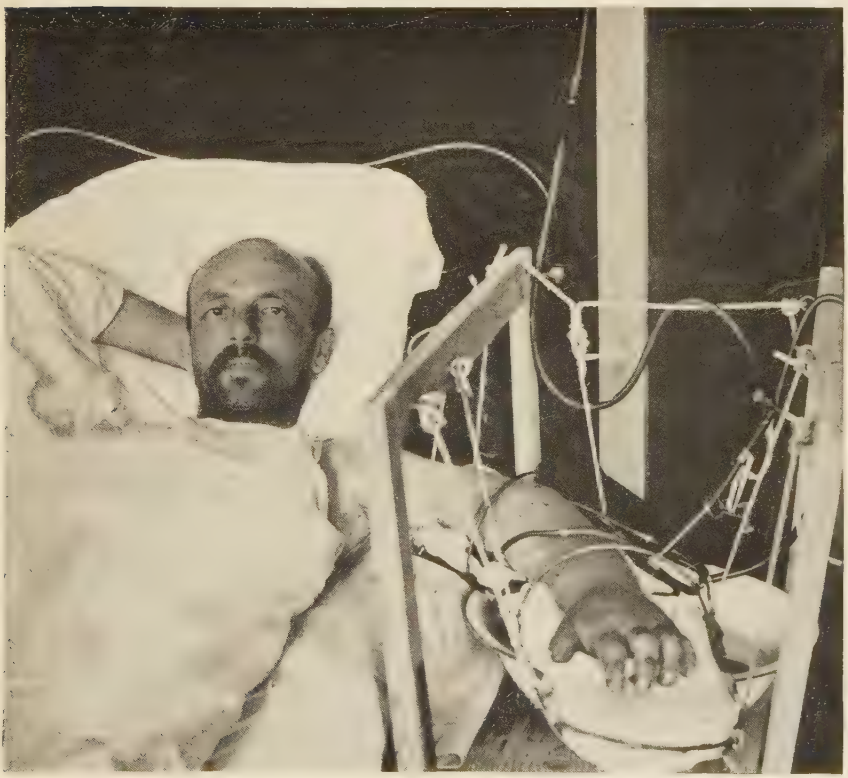


Fig. 137.—Showing Dr. Edmund B. Piper's system of hydraulic irrigation. (See page 99.)

Fig. 138.—Showing the method of trench construction and the conditions under which wounds become infected. (See page 91.)

Fig. 139.—Showing an amputation stump of a case of progressive emphysematous necrosis (gas-bacillus infection) with the apparatus applied for pulling upon the skin. This amputation was performed during the latter part of the second grade of the progressive process. The black staining shown upon the skin of the stump was caused by the silver-nitrate solution used as a moist dressing. (See page 97.)

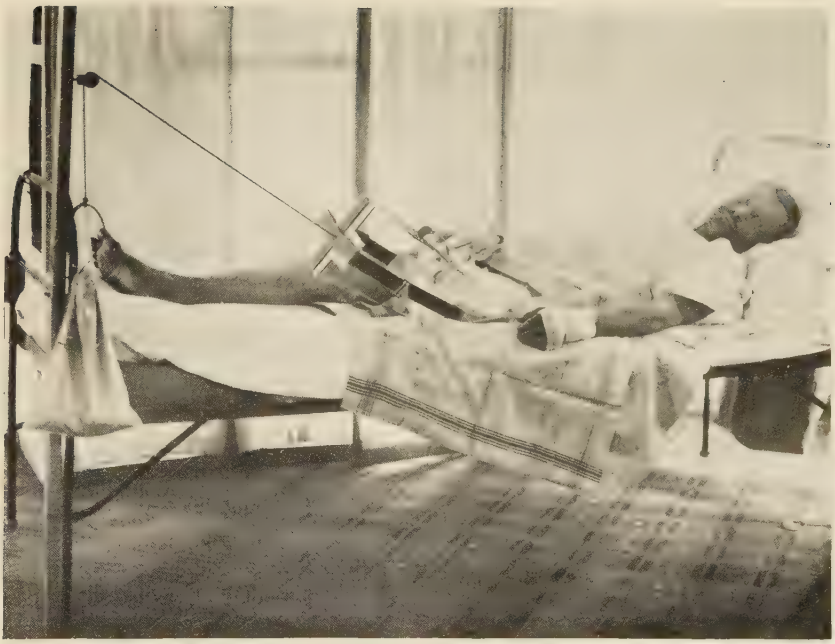


Fig. 140.—Showing the completed dressing and apparatus for skin traction in position in the same case as the preceding photograph.

Fig. 141.—The same case as the preceding showing the improvement in skin growth over the stump at the end of two weeks.

Fig. 142.—Showing an old amputation case under treatment with the skin traction apparatus. This case improved steadily, and after one month a minor plastic operation completed the cure. (See page 97.)

Fig. 143.—Showing another second-grade amputation after two weeks' use of skin traction apparatus. In this case it was permissible to allow a certain amount of skin flap at the time of operation, although no sutures were used and the wound was treated openly throughout. (See page 97.)

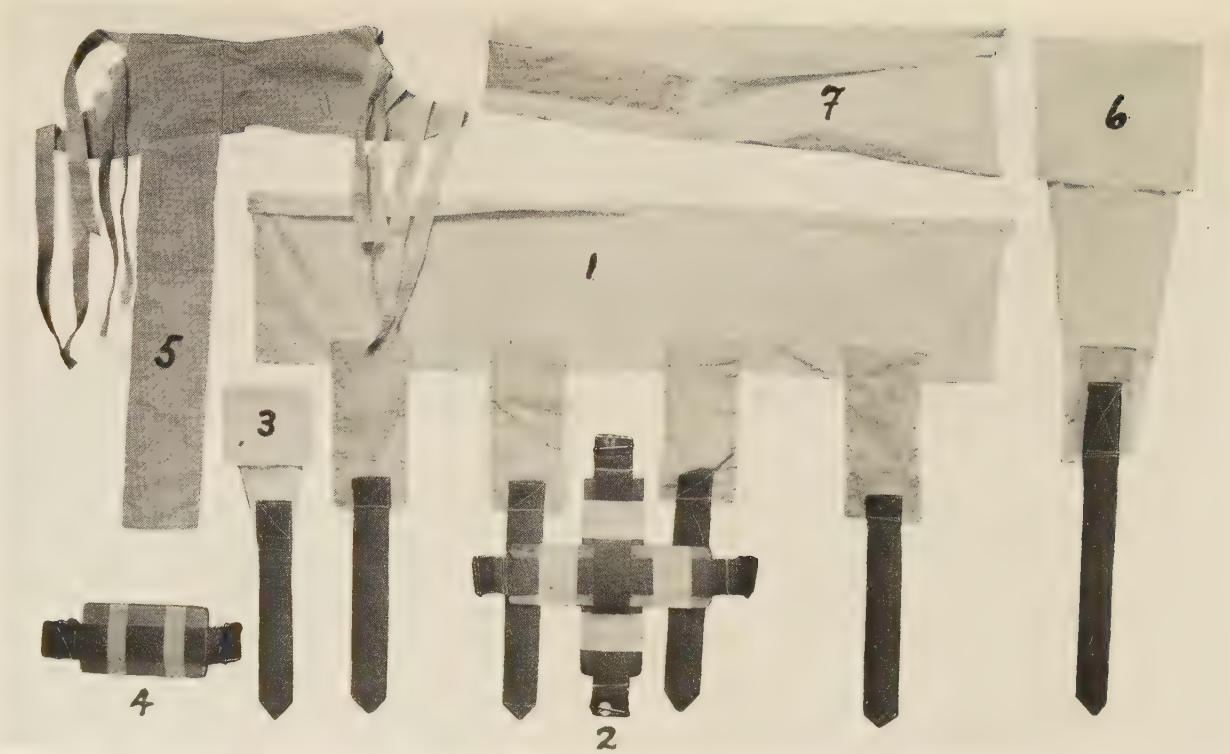
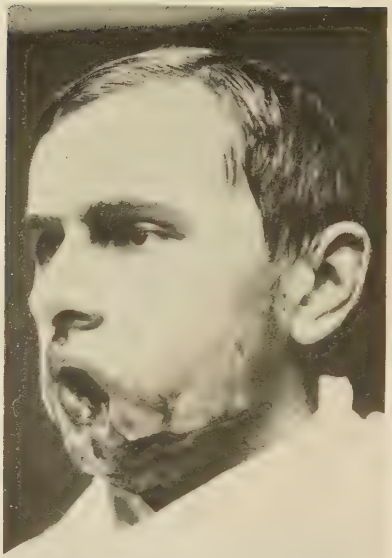


Fig. 144.—Showing the pattern of the canton-flannel extension straps used for the purposes already mentioned. The material used was a medium weight canton flannel. (1) The broad piece, with extension straps, used for the skin traction apparatus. (2) The wooden cross-piece to which the above extension straps are buckled. (3) Cloth, with webbing extension, which is glued to the forearm in the overhead extension treatment of compound fractures of the humerus. (4) Wooden traction piece to which the foregoing webbing is buckled. (5) Cloth anklet used to obtain extension on the foot in cases where the wound in the leg was low down or involved the ankle joint. The horizontal piece is secured over the dressing around the ankle, while the vertical piece turns under the plantar surface and is afterwards pinned to the horizontal piece. (6) Cloth extension strap, with attached webbing, to be glued to the leg in the application of the Blake splint. (7) A double extension cloth, the ends of which are glued to the leg, used as a substitute for adhesive plaster in the application of a Buck's extension. (See page 97.)



Figs. 145-147.—Operative stages shown in a series of three photographs of the same case. (See page 101.)

Fig. 148.—Original shell wound.
(See page 101.)

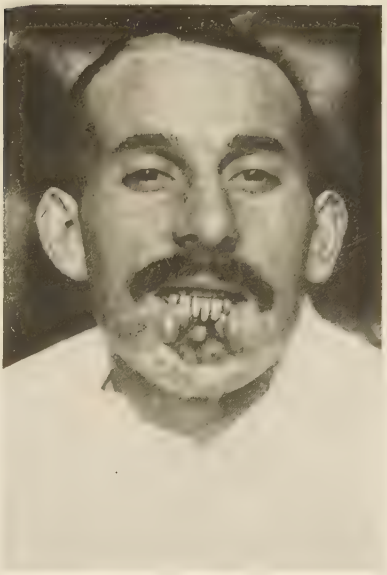


Fig. 149.—Result of partial healing and showing dental bridge

Fig. 150.—Final plastic operation performed.

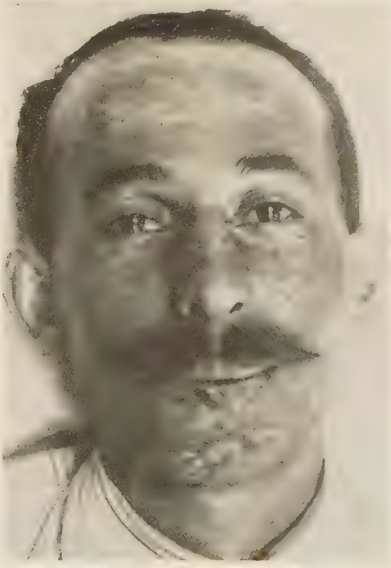
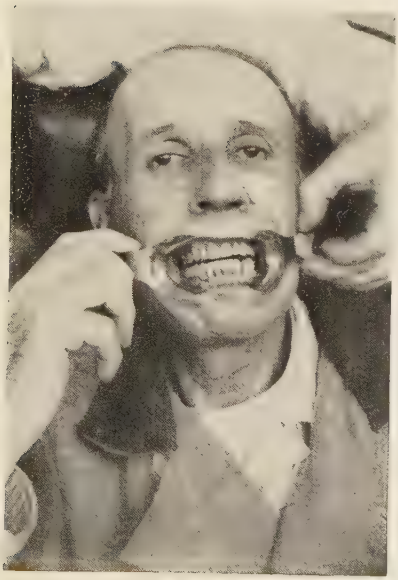


Fig. 151.—End result.

Figs. 152–153.—Showing original shell wound and the result of healing with the dental bridge in place. (See page 101.)

Figs. 154–155.—Shell wound of face, causing loss of front teeth with alveolar process, showing condition of patient (Arab) on admission and discharge. (See page 101.)



Figs. 156–159.—Showing a series of photographs of a case admitted from another hospital which had no dental service. Original wound was due to a rifle ball which entered from below and resulted in a compound fracture of the lower and upper jaws. Showing condition on admission and discharge. (See page 101.)

In view of the combined evidence of a beginning progressive local and constitutional decline, the surgeon is thoroughly warranted in deciding upon an amputation. The latter must be performed before the general resistance of the patient is so low that the shock of operation will cause death. The operation itself must be performed with the utmost dispatch consistent with the recognized principles of good surgery. The stump should be left wide open and no effort made to limit the size of the wound by the introduction of sutures. This latter admonition is highly important in view of the paramount necessity of making absolutely sure that henceforth aerobic conditions will prevail in the wound.

In order to save as much of the limb as possible it will ofttimes be necessary to disregard the formation of skin flaps on account of the position of the wound or the area involved in the necrotic process. At other times a certain amount of skin may be available as a flap covering without sacrificing the length of the limb. In either case the wound is to remain completely open during the course of the after-treatment, and the skin, if left to itself, will gradually retract and eventually necessitate a second operation in order to secure a painless and useful stump covering.

In order to prevent, or limit as far as possible, the skin retraction in these wounds, a method was devised which constantly pulled upon the skin during the period of after-treatment. This method proved to be highly successful in quite a number of these cases and is recommended on account of its simplicity and effectiveness (figs. 139–144). It consists of gluing a wide piece of thin canton-flannel material to the skin about 2 inches above the edge of the wound and with the "hairy" side of the material next to the skin. Sewn to this wide piece of canton flannel are four narrower pieces of the same material 2 inches apart and having a short piece of narrow webbing attached to each of the four pieces, as shown in figure 144.

This apparatus is not used until three or four days have elapsed after the operation, so that nothing may interfere with keeping the wound wide open. Although a certain amount of sloughing takes place in these cases, it quickly clears up under wet antiseptic dressings, and after three or four days it is safe to apply the apparatus.

It not infrequently happened that previously amputated cases, in which the wound had been left open, were admitted at the American ambulance. These cases, some of them several weeks old were also successfully treated with the skin traction apparatus.

When the wound is to be dressed (fig. 139) the extension straps are laid back and do not interfere with this procedure. Narrow strips of rubber tissue, placed crosswise, cover the raw surface, and over these are placed the wide gauze pads, which are then secured in place

by a narrow strip of gauze surrounding the dressings at the end of the stump. The extension straps are now brought over the end of the crosspiece of wood. The latter has attached to it a cord, which passes over a pulley attached to an upright at the foot of the bed and secured to a bag containing the 5 to 7 pounds of weight (fig. 140). In order to make sure that the dressings will not slip off the wound, two long narrow strips of gauze are secured crosswise over the dressing and pinned to the wide piece of canton flannel which is glued to the skin, the strips of narrow gauze passing through the intervals between the extension straps. In order to make a better pinning surface for the strips of gauze, it was necessary to apply five or six turns of a wide gauze bandage snugly over the broad piece of canton flannel. The arrangement was kept up usually for about a month, the dressings being renewed daily, and by that time the skin had usually come down over the stump to such an extent as to be able to dispense with the apparatus entirely.

The preparation used to glue the canton flannel to the skin for the traction apparatus, also to glue the extension straps to the leg in the application of the Blake splint and to glue the extension straps to the forearm in the overhead extension treatment of compound fractures of the humerus, is as follows:

	Parts.
Resin	50
Alcohol	50
Benzin	25
Venice turpentine	5

NOTE.—Powder resin; add half of the alcohol; add all of the Venice turpentine with the benzin, and then wash the measure with the remainder of the alcohol.

As regards the treatment of the third or septicemic *grade* of progressive emphysematous necrosis, there is practically nothing that can be done to ward off a fatal result. Rectal salt solution with adrenalin chlorid, slowly introduced, will aid other stimulants in prolonging life, while blankets and hot-water bottles will prevent the rapid lowering of body temperature. The serum treatment and all other measures that have been tried have signally failed when once the septicemic *grade* has begun. The only hope offered is to prevent the onset of the third *grade* by prompt amputation in the latter part of the second *grade* and before the patient is too weak to stand the shock of operation.

In a certain, though rather small, percentage of second *grade* cases the mixed infection will continue for a considerable period. Although the gas bacillus may be present in the wound, it shows no signs of activity, and the mixed infection continues, with remissions and exacerbations in spite of all that is done to control it, until the patient's condition has gradually sunk to a very low ebb. This

class of prolonged infected wounds has already been alluded to, and certain considerations were advanced with a view to bringing about a better general condition of the patient and a more favorable end result.

Dr. Edmund B. Piper, a member of the Philadelphia unit at the American ambulance, has devised a system of irrigation for deep, perforating, and badly infected wounds, on a principle of hydraulics (figs. 137 and 160). This method has been used with a great deal of satisfaction on several long-standing cases of badly infected deep sinus wounds surrounded by large granulating areas. The application of this method calls for incising the part in such a manner as to obtain thorough drainage from all parts of the wound.

The following is a quotation from Dr. Piper's personal communication to the writer:

The primary principle of the treatment of all infections is drainage. When we have established drainage by proper openings the question of rapid recovery

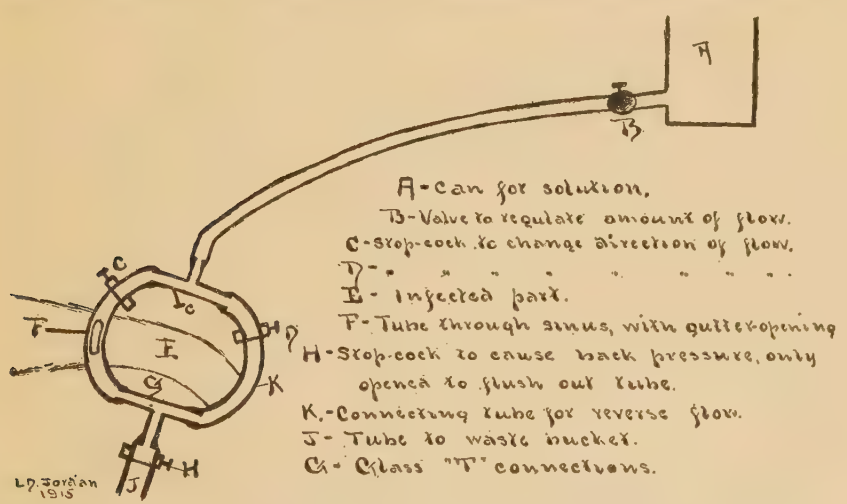


FIG. 160.—Diagram illustrating the hydraulic system of irrigation. (See fig. 137.)

unquestionably depends upon the ability to keep the infected area as free from pus as possible. In order to accomplish this we have applied the old principle of hydraulics, namely, that the only way fluid can be forced out through an opening in a tube, which opening is covered up, or rather over, by soft pliable material, is by back pressure. Therefore we cut off the flow from the end of the tube and use a through-and-through rubber drainage tube, with a gutter cut in its side. This tube is placed in the wound and the position of the opening changed from time to time to avoid granulations growing over the opening. The tube is connected above and below, and the direction of the flow regulated by stopcocks, which are explained in the accompanying rough sketch, the object of this being to alternate the flow of the fluid from above downward to below upward and vice versa. We use the continuous drop, but usually open the valve widely a half dozen times a day, and so give the wound a free flushing. Thus the fluid must pass out of the gutter opening in the

tube into the wound itself and flush out around the edge of the tube at either end, depending on where the gutter opening lies at the time and the direction of the flow of the solution, but more especially upon the former.

DENTAL SURGERY.

One of the surgical advances of the present war has been the recognition of the dentist as a necessary unit in the organization of a military hospital. This has been largely brought about by the present-day trench warfare. The latter leads to the production of a large number of face or jaw wounds, involving usually a great loss of substance, in the form of bone, teeth, and soft parts. So valuable has this work become that every large military hospital now has its surgical dental department, which works in conjunction with the other surgical services and supplements certain procedures which are indispensable as regards bringing about a favorable result.

The surgical dental department of the American ambulance, under the charge of two American dentists, Dr. Hayes and Dr. Davenport, has greatly extended its usefulness during the present year. Starting with a small equipment and one assistant, three chairs in all, it has grown to six assistants and a proportionate number of chairs and equipment. This department not only takes care of the dental cases at the American ambulance, but has treated large numbers of patients from other hospitals. A prominent part of the work has been the systematic inspection of the mouths of all patients admitted to the ambulance. This has involved a great deal of painstaking work, resulting in putting the mouths of many hundreds of patients in a healthful and comfortable condition. Many hundreds of treatments, fillings, and repair work of all kinds have been carried out, and as a result a large percentage of the patients show a general improvement of such a character as to be attributable to the dental work alone. In order to give some idea of the amount of work performed by the dental department of the American ambulance, and also to indicate the importance of a dental department in the organization of a military hospital, the following summary is made from the report of the chief dental surgeon, Dr. G. B. Hayes, covering the period from September 6, 1914, to September 1, 1915, which is practically one year of surgical dental work:

Extractions	2,658
Amalgams	1,345
Cements	627
Gutta-percha	247
Arsenic	192
Roots filled	399
Nerves removed	181
Wire splints	6

Rubber splints	14
Metal splints	88
Bridge splints	11
Gold splint	1
Obturators	2
Angle arches	4
Pivots	10
Plates repaired	9
Total number of plates (vulcanite)	383
(This latter item includes 1,948 teeth replaced.)	
Jaw cases:	
In hospital	94
Outside, but still coming for treatment	46
Under treatment	140
Finished	104
Total	244
Cleansing and prophylactic treatments	1,279
Total number of cases treated	1,523

There can be no question of the value of placing the teeth in order, as shown by the improved digestion and general good health following this work; but the great usefulness of a dental department to every hospital has only been recently generally recognized. In many instances the complications following operations are directly traceable to an unhealthy condition of the mouth. So true is this that the careful surgeon is beginning to insist upon a thorough inspection and treatment of the teeth, whenever it is practicable, before undertaking any major operative procedure.

One of the most striking features of the value of a dentist in the organization of a military hospital is shown in the results obtained by surgical cooperation with the dentists at the American ambulance in connection with the mutilating wounds of the face (figs. 145–159). These wounded always show compound fractures of the upper or lower jaw, with a variable amount of loss of substance. They represent a class of cases which extends over a period of months before a final operation is performed which completes the result. A wound of this character is considerably hampered at first with reference to the healing process on account of the secretions from the mouth and the necessary feeding of the patient. At the first operation these ragged and mutilating wounds are treated by the careful trimming away with scissors of the sloughing areas. In this procedure the vermillion border of the lip is preserved as much as possible, and then the tissues are loosely brought together with sutures and protected by a loose dressing, which has to be changed several times a day.

The preliminary steps of the operation consist of shaving the face and neck, scrubbing with green soap and water, followed by 70 per

cent alcohol. As the mouth secretions are profuse and the bleeding rather free, it will be necessary to provide means for the prompt removal of this mixed fluid from the pharynx during the operation in order not only to prevent strangulation but also the inhalation of septic material which may cause pneumonia. This is best accomplished by a simple water-suction apparatus secured to a faucet in the operating room and having a long tube attached which ends in a good sized catheter. This latter is held in the pharynx by an assistant during the operation, and the fluid is thus removed as it accumulates.

The most that is hoped for from the first operation is that the soft parts will unite in such a way as to admit of correcting any serious deformity later on by means of a final plastic operation. There are usually three stages in the general operative procedure. The first stage consists of bringing the soft parts loosely together, as indicated above. Usually there is so much loss of bony substance that no effort can be made at this time to unite the fractured ends of the bone.

After the soft parts have united, the second or dental stage is begun. A metal bridge is anchored, by the dentist, on whatever teeth remain at the ends of the fragments. This bridge may be temporary at first for the purpose of simply holding the loose fragments in a steady position in the mouth. Gradually a scar will form over the ends of these fragments and the continuity of the mucous membrane of the mouth is slowly restored over the scar thus formed. The condition of the parts at this time is fairly satisfactory, although there may be considerable puckering as a result of the partial or complete healing of the original wound. Once the mucous membrane has grown over the scar between the bone fragments the third stage of the operation may be attempted. This consists, first, of a plastic procedure, which is directed toward as complete a restoration of the face as is compatible with the destructive effects of the original wound and the available skin in the immediate neighborhood of the scars. The second step consists in the removal of a portion of a rib, or of the tibia, which is then transplanted to complete the bony continuity of the jaw beneath the bridge.

In proceeding with the plastic operation on the skin, it may be necessary to partially remove the scar so as to bring about a better readjustment of the tissues. Injury to the newly formed mucous membrane must be carefully avoided, but if it is necessary to incise it, or if accidentally wounded, it must be carefully sutured. Having outlined the plastic work by the formation of suitable skin flaps, the ends of the bony fragments are carefully dissected free from the scar tissue so that no injury results to the underlying mucous membrane. The ends of these fragments are now freshened by either beveling

or grooving. An accurate estimate is then made of the bone required to bridge the gap and a suitable piece of rib with periosteum may be resected, or a portion of the tibia with its periosteum may be removed, according to the preference of the operator.

There are several ways of securing the transplanted bone in place. It may be beveled and fitted into corresponding grooves at the ends of the fragments; it may be drilled and sutured in position with chromic gut; or, if the conditions are favorable, some form of bony inset may be attempted along the lines of a mortise and tenon joint. Having fixed the bone in place, the skin flaps are sutured and boric acid dusted over the suture lines. The after-treatment consists of careful liquid feeding and frequent mouth washing.

INJURIES TO THE NERVOUS SYSTEM.

In a personal communication, Dr. C. B. Craig, of New York City, who has had charge of the neurological cases (figs. 161–167) at the American ambulance for eight months, gives the following outline of his observations:

In classifying the cases in a large base hospital such as this, one must keep constantly in mind that the proportion of injuries to vital parts, as compared to less serious injuries, is almost opposite to that seen in the front hospitals—that is to say, the majority of men wounded in brain, spinal cord, abdomen, or heart die on the battle field or at the first-aid stations.

The cases in a large base hospital present a percentage of probably 80 in which the wound is in an extremity. During eight months I have not encountered a bayonet wound, which is accounted for by the fact that most bayonet wounds are in the abdomen and the men consequently die on the battle field. Injuries to the head form a rather large percentage at the American ambulance owing to our specialization in the after-treatment of jaw wounds. Injuries to the brain form a small proportion, and of these over 90 per cent of the penetrating wounds of the brain have resulted in death from meningitis. Those cases which have recovered have, in many instances, formed secondary abscesses in the course of a few months. Cases of concussion, where the brain has not been affected, have recovered with remarkable rapidity. I have seen examples of complete hemiplegia clear up to a large extent in six weeks, and as far as function is concerned entirely in three months.

Injuries to the spinal cord may be divided into direct trauma with laceration of the cord or a severe degree of contusion, and concussion with hematomyelia produced by a sharp blow upon the vertebræ. The former class is rendered paraplegic, and of the 12 cases I have observed very little progress has been made—in fact, one may say none of importance, as the patients remain paralytic in both legs and incontinent. The second class—result of hemorrhage into the spinal cord—occurs chiefly in the cervical region from wounds of the neck; the picture of complete paralysis of both arms with preservation of motor power in the legs is the commonest one. The six cases of this variety which I have observed recovered the use of arms almost completely. Injuries to the nerve trunks make up by far the largest proportion of traumata of the nervous system.

It is difficult to classify cases as distinctly neurological, as practically all instances of fracture in an extremity show varying degrees of disability of the

peripheral nerves below the point of injury. The suspension of function in the peripheral nerves may be due either to direct violence of the missile, flying fragments of bone, or to the resulting hemorrhage and edema into the part, or to cicatrization; and the subsequent disability may be motor or sensory, or both. Mild cases resultant upon edema and hemorrhage have recovered regularly, providing that the hand or foot has not been kept motionless. One of the chief discoveries of importance which the treatment of numerous cases of fracture at this hospital has brought out is that the hand or foot beyond the fracture should not be allowed to remain motionless or strapped to a splint, but should be exercised and given massage at the earliest possible date. In this way many stiff joints and trophic changes in the fingers (including skin and tendons) have been avoided. An excellent device has also been found to suspend fractured arms, thereby preventing stasis and aiding the subsidence of the usual edema.

Injuries to nerve trunks naturally follow the same general rules as one observes in civil practice, i. e., injuries to the sciatic are much the more painful, whereas injuries to the nerves in the arm are much more apt to result in motor paralysis. The commonest motor paralysis is that of the musculospiral, due doubtless to its location close to the humerus. Considering the enormous number of wounds in the extremities, both of the bones and soft parts, the infrequency of completely severed nerves is quite remarkable. This must be accounted for by the resiliency and elasticity of the nerve trunks, which permit a certain degree of displacement without rupture.

In the treatment of peripheral nerve injuries the following has been found of service: The coal-tar products, in proper dosage, usually afford relief; combinations of aspirin, phenacetin and sodium bromid have been very useful; and at night a combination of aspirin and veronal has proved efficient. When necessary, of course, morphin is resorted to. When the nerve lies in an open wound, or even after the wound is closed, a direct application of electric-light rays from an ordinary incandescent lamp has been found to give relief. Elevation of the extremity, to increase the mass movement of the blood and decongest the irritated nerve, has been very beneficial in many cases. After the wound is fairly on the road to recovery an electrical current has been used with good effect, both galvanic and faradic, to maintain the nutrition of the parts supplied while the nerve is recovering.

In view of the long convalescence which patients suffering from injuries to the nervous system are bound to undergo, one of the most important features of their care is the establishment of suitable convalescent homes where proper treatment can be continued after their discharge from surgical hospitals, otherwise the inclination to disuse of the wounded member will render the individual in all probability a cripple for life.

Dr. Stone, a former neurologist at the American ambulance, in a paper read before the medical society of that institution, has this to say with reference to the surgical treatment of certain severed or functionless nerves:

In certain cases, operative measures have been undertaken for two purposes; one to improve the motor function in certain nerves, such as the musculospiral, where the nerve has been caught in the callus or cut in two by the fragments of the humerus; and the second, to diminish the amount of pain which the individual suffers, as for example, in cases of the long saphenous caught in a scar and as a result of which the patient suffers much pain in the distribution of this nerve.

These operative measures occurred in several instances, but undoubtedly operations will be still more necessary in this group of cases before the patients are returned to the best condition in which they can be placed. One must realize, too, that convalescence is tremendously long in these operative procedures. Someone has computed—though this computation may perhaps not be quite correct, yet it is valuable as a means of comparison—that a nerve in a young individual, with everything in his favor, will regenerate at about the rate of 1 cubic mm. a week. If, therefore, a man has a fractured humerus, and the musculo-spiral nerve, caught in the callus, has been released, and if he has everything else favorable to his recovery, it will take a matter of 25 to 30 weeks at the shortest space of time before he returns to a condition at all approaching his normal.

As a matter of fact, very few recover entirely, for the reason that most of the injuries are associated with infection, and infection very decidedly diminishes the chance of the individual having the nerves functionate again in the normal way. When one considers the number of instances of nerve lesion, the severity of the symptoms which may be produced, and the long convalescence which must ensue before these individuals are returned to a normal condition, it is not very difficult to arrive at the conclusion that the neurological aspects of projectile wounds are of a very definite importance.

As regards the influence of cold in the production of incapacitating defects, there have been various degrees of this condition during the winter months of the present war, chiefly manifested in the region of the feet. There is a certain group of these cases which presents practically no external evidence of trouble. They complain of more or less continuous pain, chiefly at night, over the anterior aspect of the foot. The increased warmth to the part, as a result of the bed clothing, would seem to account for this manifestation. In addition to this, various forms and degrees of paresthesias are complained of, and the crippling effect, when the patient tries to walk, is pronounced. These cases linger on for a longer or shorter period, the average being about a month, before they are able to return to duty. During this time there is no swelling, discoloration, or venous dilatation visible, nor are there any other save subjective sensations to indicate an incapacity. No form of treatment seems to have any influence on the condition, although elevation and exposing the feet to the air at night seem to afford some relief.

A number of observers in the hospitals near the front believe that this condition arises from a combination of circumstances. They agree that the factors which cause the condition are a more or less tightly applied puttee, the standing for long periods in an upright position without moving the legs, and the damp cold of the trenches. The influence of long standing, in tight puttees, without exercise, causes a certain degree of venous stagnation in the leg and foot. This is evidenced by the feeling of increased constriction under the puttee and a heavy sensation in the limb. When the effect of cold, often in the form of icy water, is added to the above, it is easy to

understand that the peripheral nerves become decidedly affected by this combined influence and eventually a peripheral neuritis develops. This would seem to be borne out by the fact that the Belgian soldiers, who rarely ever wear puttees, are almost never affected in this manner, whereas the French and English soldiers, all of whom use the puttee, often become easy victims. It would seem that the condition could be prevented by wearing loosely applied puttees or leggings and exercising the legs while in the trenches in order to promote the flow of venous blood.

As regards the condition known as "frostbite" (figs. 168 and 169), there have been only five cases at the American ambulance. Formal amputations were performed on several cases, while in others the toes gradually dropped away as a result of the dry gangrenous process. Dr. Stone (quoted above) believes that the shrinking of the boot in the continuously wet and cold trench is the principal cause of this condition. He states that "shrinking of the boots diminishes the circulation of the foot and the result is a combination of diminished local circulation plus the presence of the constricting action of the cold on the blood vessels, which is followed by a definite vasodilatation from paralysis or from the vasomotors."

Unquestionably a well-fitting and well-made shoe is a most important factor in a soldier's life, and it is very probable that one of the principal reasons why the vast majority of troops escape is because of their usually excellent shoe. This latter is a light brogan type, and, while it might be improved as a marching shoe, it is waterproof and is specially made to withstand the rigor of trench warfare.

The electric vibrator and magnet perfected by Prof. Bergonie, of Bordeaux, has proved itself useful on a number of occasions. The vibrator, which is shown attached to the swinging wall bracket in figure 170, is used to locate pieces of steel in the tissues during the course of an operation. One end of the vibrator is protected by a sterile towel and brought to within a half inch of the skin surface and the current turned on. The operator's finger is held between the end of the vibrator and the skin. If steel is present in the tissues, it causes a well-marked vibration in the metal and this vibration is imparted to the surgeon's finger, which is palpating the skin. The nearer the surface, the greater the vibration in the metal, and as the end of the vibrator is moved to or from the metal the vibrations increase or diminish, as the case may be. It produces no effect on shrapnel balls, as the latter are lead, but it is useful in determining the presence of, or locating, a piece of shell or jacketed bullet, particularly if the X-ray plate is not clear. It is necessary to place the patient on a wooden operating table when the vibrator is used, as a metal table would interfere with the vibratory effects.

The magnet, which is provided with suitable steel tips, is specially applicable for extracting small pieces of metal (lead excepted) from certain inaccessible parts of the body, such as the brain, neck, or chest. In these localities it would often require a formidable operation to remove the metal by incising and dissecting the tissues. In case a piece of metal is located in one of these situations by the X-ray plate, the patient is anesthetized in the X-ray room, and there, with the aid of the fluoroscope, the operator can introduce one of the various steel tips, which has been previously sterilized, into the original wound until it can be seen to touch the piece of metal. When the operator is satisfied that the steel tip is touching the metal, the patient is wheeled into the operating room, with the steel tip carefully held into position, and the electromagnet is swung over the steel tip until it touches the latter. The current is then turned on, and this of course converts the steel tip into a strong magnet. The tip can then be gently withdrawn, the magnet being moved at the same time, pulling the piece of metal projectile with it. As shrapnel is very seldom used at the present time, the vibrator or magnet can be used practically for all pieces of projectile in wounds except a lead bullet which has lost its steel jacket.

One of the special and unusual features of the organization of the American ambulance is the department presided over by Miss Gassette, an American lady of Chicago. In this department all the bandage and dressing material used in the hospital is made up into appropriate sizes (fig. 171). In addition to this, a large amount of dressing material is sent out from here to various units over which the ambulance exercises a maternal care. A well-equipped carpenter shop is one of the adjuncts of this department, and with its aid Miss Gassette plans and makes practically all the splints and special apparatus used in the hospital. A great deal of thought and labor is expended on designing and constructing special apparatus in this department to suit the individual needs of every case. The department has grown enormously since the organization of the hospital, and it is safe to say that Miss Gassette and the numerous ladies working under her are responsible in large measure for the good reputation which the hospital enjoys.

The minister of war requires every hospital to send in weekly reports to the *Service de santé* on all the cases under treatment. In addition to this there is a special blank form in the shape of a postal card, officially franked, which is sent every week to the nearest relative of every patient. This post card gives accurate information from week to week to the father, mother, or wife of the patient as regards his condition. Every patient in the hospital is under the disciplinary control of the surgeon-in-chief, who, with the consent

of the medical board and committee, establishes such rules and regulations as may be deemed necessary.

PATHOLOGICAL CONSIDERATIONS IN BASE HOSPITAL WORK.

With the idea of throwing an interesting side light on certain morbific factors which have to be considered in connection with the general work of a surgical base hospital, Dr. Kenneth Taylor, who has been the pathologist at the American ambulance since almost the beginning of the war, prepared at the request of the writer the following instructive paper, which analyses the post-mortem findings in 51 autopsy reports:

In view of the frequent occurrence of pathological lung conditions revealed at routine autopsies in this ambulance, it was decided to review the total number of autopsies on record, with the idea of ascertaining the frequency of pathological conditions of the lungs and pleura among the fatal cases.

Fifty-one autopsy reports have been examined, comprising all in which an examination of the chest was made. The following is a list of the number of times in which a pathological condition was recorded:

Lobar pneumonia	6
Bronchopneumonia	15
Plastic fibrinous pleurisy	27
Pleurisy with effusion	8
Empyema	2
Passive congestion (extensive)	2
Hemothorax	4
Pneumothorax	1
Negative findings	9

Many of the cases presented several conditions; for instance, 5 out of 6 of the lobar pneumonias showed adherent pleura, while 9 out of 15 bronchopneumonias showed a similar condition. The total number of lesions is therefore in excess of the number of cases autopsied. An attempt has been made to classify the injuries, taking those which seemed most responsible for the death of the patient. The following is a list of the occurrence of such injuries:

	Number of cases.	Lungs, negative.
Penetrating wounds of the chest	5	.....
Penetrating wounds of the abdomen	4	1
Transverse lesions of cord	4	.....
Penetrating wounds of brain	10	3
Wounds of thigh	17	1
Wounds of leg and other extremities	6	2
Multiple wounds, too numerous to classify	4	2

Combining the list of injuries with the list of lung findings, we find that 43 showed definite macroscopical pathology; in all of the 5 penetrating chest wounds; in 4 of the 5 penetrating wounds of the abdomen; in 3 of the 4 cord injuries; in 6 of the 10 brain injuries; in 16 of the 17 wounds of the thigh; in 6 of the 8 wounds of other extremities; and in 4 of the 6 cases of multiple wounds, pathological conditions of the lungs or pleura were present.

Further analysis of the 9 negative cases which occurred (1 in a penetrating wound of abdomen, 3 in penetrating wounds of brain, 1 in wound of thigh, 2 in wounds of other extremities, and 2 in cases of multiple wounds) shows that 4 died within five days of injury, a time too short for chronic changes of the lungs to have taken place.

The cases in which pathological lung conditions are certainly to be expected are, of course, those in which there is a penetrating wound of the chest and probably also high transverse lesions of the cord—which together comprise 9 of the 43 cases showing pathological conditions. This leaves a total of 31 cases out of 51 autopsies in which the lung condition seemed to bear no direct relation to the wound. Some of these, especially a few of the acute bronchopneumonias, are undoubtedly to be explained as part of a general pyemia or septicemia. On the other hand, there is left a large proportion of cases in which it is difficult to see any direct relation between the wound and the condition in the chest. The high occurrence of lung conditions in wounds of the thigh (16 out of 17—94 per cent), as in penetrating wounds of the abdomen (4 out of 5) and in transverse lesions of the cord (4 out of 4) suggest that the chronic degenerative changes manifested in the great number of adherent pleurae, may possibly be connected with the matter of posture as well as the general intoxication from the wound itself. Presumably the acute lung conditions were more or less dependent upon the chronic changes in the pleurae.

It is worth noting that this high incidence of pathological lung conditions has occurred in a class of patients which should be fairly free from lung affections. All are men between the ages of 20 and 40, who are supposed to have passed a more or less rigid medical examination and who have been living an out-door life for several months.

In conclusion it may be stated that 90 per cent (46 out of 51) of the wounded dying 5 days or more after injury have shown at autopsy some gross pathological condition of the lungs or pleurae sufficiently marked to be more or less active in preventing recovery from the wound. In more than half (27 out of 51) of these this change was of a chronic degenerative character, unexpected in civil practice in patients of this age and state of health. By far the greatest number of cases was in the type of wound enforcing a dependent position in bed.

Influenza has been a more or less annoying and serious factor during certain times of the year among not only the patients but also the doctors, nurses, and orderlies, who have all shown a high incidence of this disease. On one surgical service alone at the American ambulance there were 42 cases out of 170 patients at a time when the disease was apparently pandemic. Other hospitals all over the country were similarly affected, so that the influenza bacillus is not to be regarded too lightly in connection with the pathology of a surgical base hospital.

Of the 42 cases referred to above 32 were acute throats with comparatively little respiratory involvement. The other 10 include 5 chronic bronchial affections and 5 acute bronchopneumonias. Only cases in which the bacilli were found in abundance in the swabs from the throat or in the sputum are included among this number. Many cases of slight headache, sore throat, and general malaise are omitted because of insufficient observations to justify a positive diagnosis.

Dr. Kenneth Taylor (quoted above) has the following to say in regard to the harmful presence of influenza at the American ambulance during the time it was prevalent at this institution.

It may directly increase the mortality among patients. We have lost no patients during the last six weeks of our service from influenza, but have had two acute post-operative and three spontaneous bronchopneumonias due to this infection, any one of which might have terminated fatally.

The infection may cause direct permanent damage to the patient, indepeently of any other infection. In this connection I may mention that two cases of myocarditis, three of otitis media, and many cases of persistent bronchitis have arisen among the patients with influenza.

It may increase the length of or obstruct convalescence indirectly by affecting adversely the progress of recovery on surgical conditions. For example, one patient with a very slight degree of frostbite had been seriously ill for three weeks with bronchopneumonia of influenzal etiology.

Influenza may increase the cost of caring for the patient and impair the efficiency of the hospital by the enforced absence of doctors, nurses, and other members of the hospital force. One-half of the nurses and auxiliaries in this unit have been absent on account of influenza from two days to two weeks—a total of 67 days lost to be charged to influenza during the past six weeks. Other cases among nurses which I have not personally seen would probably double the number.

While the pandemic character of influenza is well known, much can be done hygienically to prevent or limit its occurrence. It was found that dampness seemed to play a prominent rôle in imparting an epidemic character to the disease. The hospital floors were washed every day, and at first they remained damp for a considerable time. When attention was called to this and to the fact that the windows of the hospital could be judiciously kept open, the disease rapidly subsided after corrective measures had been taken. During the pandemic manifestations of influenza the large number of visitors always present at times in a large hospital would also seem to be a factor in its dissemination. While there did not seem to be any manifestation of bed to bed contagion, the fact that a large number of nurses were affected at one time or another would seem to point to the fact that they aided somewhat the spread of the disease. Doctors, nurses, and other attendants should not remain on duty or in contact with the patients while they are suffering from sore throats or any other manifestations of this disease, however mild.

Secondary hemorrhages are vitally important factors in surgical base-hospital work for the reason that infected wounds have always been prone to this complication, especially after amputation where active infection is a feature of the case. The surgeon has to be continuously on his guard to meet this emergency in the wards of a base hospital. Quite a number of deaths are due directly and indirectly to this serious complication. Ward routine should always take cognizance of the probable occurrence of some degree of hemorrhage in

recent operative cases of the character noted above. However careful the hemostasis may be at the time of operation, a certain number of these cases will develop and cause no little anxiety until convalescence is well established.

Transfusions have been the means of saving a number of these cases and have allowed certain operative measures to be carried out later which eventually proved successful. Ligation of the vessel in continuity is one reliable means of controlling the condition, although packing, or ligating the bleeding points have been successfully carried out a number of times in the less serious cases. Careful and delicate handling of the tissues at the time of operation, the removal of foreign bodies and all loose or sharp-pointed bone, together with careful hemostasis and the not too forceful application of ligatures, will largely reduce the number of these distressing conditions.

Dr. Robert B. Greenough, chief of the Harvard section of the university service at the American ambulance, in a personal communication to the writer, gives some impressions of his work, as follows:

As I get to the end of my three months' service at the American ambulance I find that certain features of the work have impressed themselves especially upon my attention. My base of comparison is, of course, that of a surgeon in a civil hospital, as I have had no previous experience in military surgery. The different points which would seem to me worthy of mention are as follows:

Infection.—When we first came to Paris the conditions were somewhat different from those in the latter part of May and June when the weather was warm and dry and the conditions at the front more favorable for cleanliness. The majority of wounded received at this hospital reach there 48 to 72 hours after they have been wounded. As a rule, first-aid dressings and iodin have been applied at the front and a more elaborate dressing by a surgeon has commonly been performed at a first-line or evacuation hospital 12 to 24 hours before entrance. Cultures taken of these wounds at entrance in April showed in almost every case a mixed growth of organisms, including gas-forming anærobic bacilli. In May and June the mixed growth of organisms continued, but the gas bacillus, though occasionally present, was not constant.

Our routine treatment of these cases involved an anesthetic dressing, at which the wound of entrance was enlarged and fragments of clothing, if present, were removed. In wounds of the arms, legs, and trunk these fragments were almost constant, a fact which we attributed to the peculiar short-fiber texture of the French military uniforms. Foreign bodies, such as bullets and fragments of shell, were removed at once if readily localized and reasonably accessible, without incurring the danger of dissemination of infection. Bone splinters, detached from periosteum, were also taken out; the wounds were almost always irrigated with salt solution or sodium hypochlorite, 1 to 200, at operation, and often subsequently either by constant drip or by application of wet dressings. Where the soft parts were seriously necrotic, whether from injury to blood supply or by trauma alone, this necrotic material was removed, on the ground that its presence favored enormously the growth of the gas bacillus. The attempt was made to immobilize the part either with splints of wood or metal, or with plaster-of-Paris dressings, of which Dr. Osgood, our orthopedic surgeon, devised many ingenious types. The immobilization was, of course, of the greatest importance in the fracture cases.

Although the primary cleaning up of these wounds under an anesthetic I believe to be very necessary, the after-treatment of the case is almost, if not quite, of equal importance. Our service was particularly fortunate in having five house officers who were experienced in civil-hospital surgery, and the benefits of careful daily dressings, the arrangement of apparatus for irrigation, and the continuous supervision of the cases gave results in the way of prompt subsidence of inflammation, which I think would not otherwise have occurred. In this connection the use of rubber-tissue drains in preference to tubes and the protection of the wound by sheets of rubber tissue seem to us to give much greater comfort to the patient and to be on the whole the most satisfactory dressing. By this method of treatment rapid subsidence of the infection, whether of the ordinary mixed type or with the gas bacillus, would confidently be expected. A vigorous temperature reaction of 103° or 104° F. followed as a rule. After two days, however, this came down gradually, and the further progress toward recovery was so rapid that it could be attributed only to the excellent general physical condition of the patients. In only a very small percentage of cases, 1 or 2 per cent, did primary healing follow the application of a first-aid dressing, whether the missile remained in the body or whether it was a perforating wound.

Compound fractures.—These formed the greater part of the wounds that were brought to us at the American ambulance. These were produced both by shell fragments and by bullets. Owing to the close proximity of the opposing trenches, most of the bullet wounds showed very strikingly the so-called "explosive action" of the small-caliber high-velocity projectiles received at short range. The shafts of such long bones as the humerus or femur were often shattered into innumerable little fragments, and these fragments as secondary missiles were driven through and into the tissue toward the wound of exit over a cone-shaped area of wide extent. Fractures produced by shell fragments were more atypical, but were almost always comminuted and irregular, owing to the irregular shape and size of the projectile.

Under anesthesia we removed as far as possible the fragments of splintered bone, partly because they were capable of acting as foreign bodies and maintaining continuous suppuration, partly because they produced necrosis of the muscle in which they lay and thus favored the growth of bacteria, especially the gas bacillus, and partly because of the possibility when so situated, from an anatomical point of view, of subsequent injury to blood vessels and secondary hemorrhage. All of these fractures were immobilized in apparatus; in only one case was an attempt made to fix a septic compound fracture by operative means such as bands or plates. Under this treatment long continuous suppuration could be accepted as positive evidence of necrotic bone fragments or foreign bodies which had not been removed. The majority of compound fractures thus treated showed remarkably rapid regeneration and union of such long bones as the humerus, occurring in a number of cases in between six and seven weeks. When a great loss of substance occurred in the bone and the periosteal regeneration was inadequate, preparation for bone grafts was begun, but no case presented itself during the period of our service suitable for such an operation on any of the long bones. I am confident, however, that many operations of this sort will be indicated in the next six months.

Foreign bodies.—I came to this service convinced that foreign bodies in the tissues without evidence of infection were better left alone. There appear to be, however, very few cases where this ideal condition can be obtained, as infection is almost invariably present under the condition of trench warfare. At the first dressing under anesthesia it was our policy to remove the missile, as

Fig. 161.—Showing rifle-ball wound of wrist with anesthetic area outlined due to severed ulnar nerve. (See page 103.)

Fig. 162.—Area of ulnar anesthesia (outlined) due to rifle-ball wound of forearm. Note faulty desquamation. (See page 103.)

Fig. 163.—Both ulnar and internal cutaneous nerves severed from shell wound of elbow. Complete anesthesia bounded by short continuous line, pain and temperature anesthesia by dotted line, and light touch by long continuous line. (See page 103.)

Fig. 164.—Severed musculo-spiral nerve from shell wound of upper arm. The dotted line represents complete anesthesia to pain and temperature. The continuous line represents anesthesia to light touch. The upper area outlined is due to the cutting of a branch of the external cutaneous. (See page 103.)

Fig. 165.—Severed sciatic nerve by a rifle-ball injury of the thigh. The line about the foot shows area of complete anesthesia to pressure, temperature, pain, and touch. The dotted line includes area anesthetic to pain and temperature. The outer line represents area of anesthesia to light touch. Note trophic ulcer. (See page 103.)

Fig. 166.—Area of anesthesia due to severing the long saphenous nerve as the result of a shell injury to the thigh. The dotted line includes area anesthetic to pain and temperature. The continuous line represents area of anesthesia to light touch. (See page 103.)

Fig. 167.—A corner of the massage room at the American ambulance. (See page 103.)

Figs. 168 and 169.—Showing different degrees of frostbite. (See page 106.)

Fig. 170.—Showing the electric vibritor and magnet; the former is attached to the swinging wall bracket and is used to locate pieces of steel in the tissues. The magnet, with its different size tops, is on the table and is used to extract pieces of steel from certain inaccessible parts of the body. (See page 106.)

Fig. 171.—Showing one of several large rooms, in charge of Miss Gassette, where bandages, dressings, and splints are made. (See page 107.)

Fig. 172.—Showing the interior of a trench, with a machine gun in readiness to repel an attack. (See page 117.)

Fig. 173.—Showing the general construction of a firing trench, the use of the trench telephone, and the occupants on the lookout for any sign of the enemy. (See page 117.)

Fig. 174.—Showing a boyau leading back from the reserve trenches. (See page 118.)

Fig. 175.—Showing a communicating trench. (See page 117.)

Fig. 176.—Showing a network of intercommunicating trenches in the foreground and a German shell bursting in the background. (See page 117.)

Fig. 177.—Showing a wounded man awaiting transportation at a "refuge spot" at the end of a boyau. (See page 118.)

Fig. 178.—Showing one of a large number of trenches in which French dead are buried. (See page 119.)

Fig. 179.—The burial of a German officer by French soldiers on the field after the battle of the Marne. (See page 119.)

Fig. 180.—Showing a portion of a large French camp close to the front. Note the helmets for protection against asphyxiating gas on some of the men who are being mustered for a march to the trenches. (See page 121.)

Figs. 181–183.—Showing the method of carrying the food to the trenches after it has been prepared. (See page 119.)

Fig. 184.—Showing the location of a British field kitchen near the front. (See page 119.)

Fig. 185.—An adjunct to an English field kitchen located in a grove of trees. (See page 119.)

Fig. 186.—Indian troops preparing an evening meal in their camp near the front. (See page 119.)

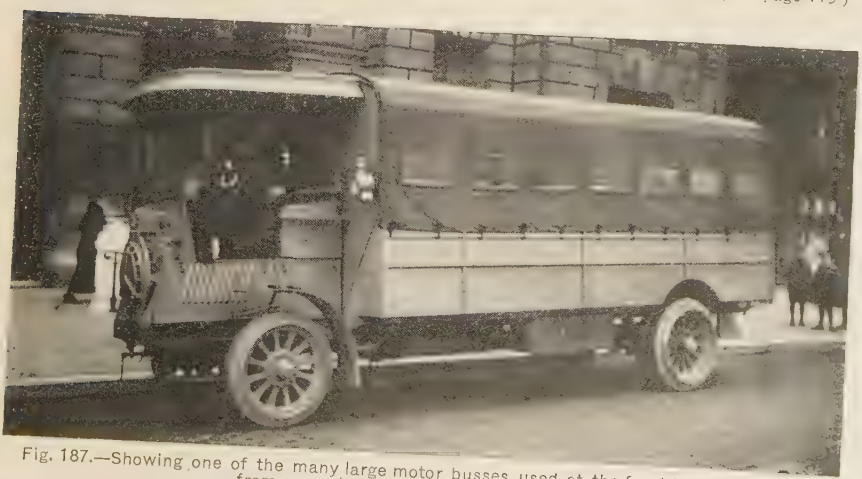


Fig. 187.—Showing one of the many large motor busses used at the front to transfer troops from one point to another. (See page 125.)

Fig. 188.—Common house fly (Musca domestica). (1) Eggs, (2) larva, (3) pupa, (4) perfect insect. (See page 122.)

Fig. 189.—Urinal fly (Scatella urinaria).

Fig. 190.—Flat horsefly (Hippobosca equi).

Fig. 191.—Blue meat fly (Calliphora vomitaria).

Fig. 192.—Green meat fly (Lucilia caesar).

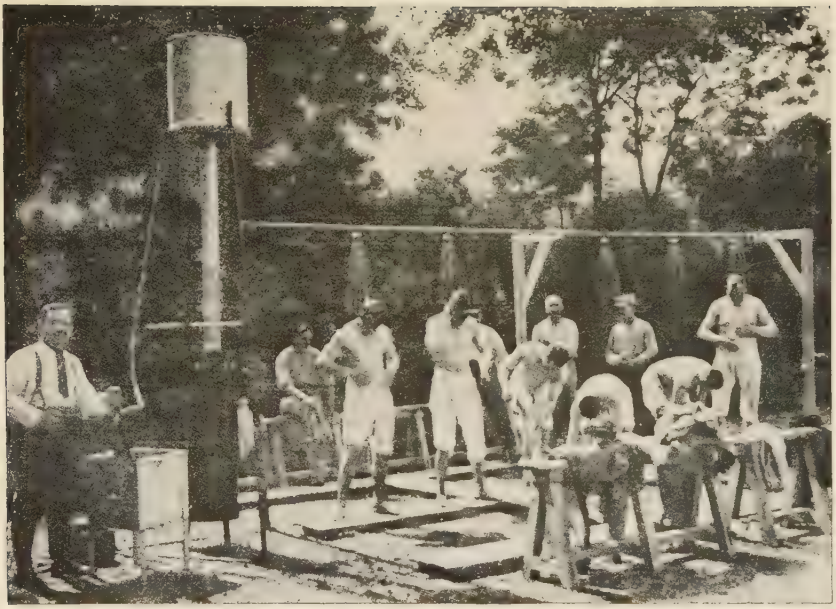


Fig. 193.—An improvised shower bath for men returning from the trenches. (See page 122.)

Fig. 194.—Photograph of Gen. Joffre in his own home. (See page 125.)

well as the particles of foreign material, such as clothing, and the bone splinters carried in with it, unless such removal in a septic wound involved considerable spread of infection to important structures. If the foreign body was not readily accessible, its removal was postponed to a later operation, when X-ray plates or fluoroscopy could be utilized for its localization. When dealing with steel fragments of shell the electromagnet and the vibrating magnet were both of service.

Secondary hemorrhage.—We have had two cases of secondary hemorrhage, in both of which the main artery of the limb became eroded in a septic wound; both cases required ligature and amputation, and both recovered, one after transfusion. In each of these cases of secondary hemorrhage adequate fixation was not obtained; all of the bone fragments had not been removed and sepsis had not been thoroughly controlled. I feel quite sure that these factors must contribute greatly toward the ocurrence of secondary hemorrhage.

Anesthesia.—No single method of anesthesia seems to be universally preferred. Nitrous oxid alone or with oxygen is suited to short anesthesias where muscular relaxation is not necessary. Chloroform is useful for ward dressings and ether was with us the anesthetic of choice for most of our operative work. The Connell apparatus proved extremely useful for all major operations, and especially in those about the head and face. Spinal anesthesia was used in a number of cases of amputation and appeared to be valuable in diminishing the symptoms of shock.

Transfusion.—At the base hospitals the occasions for transfusion are practically limited to cases of secondary hemorrhage or cases of severe wasting sepsis. For this operation a simple and convenient apparatus for vein-to-vein transfusion appears to be desirable, and these conditions are fulfilled by the apparatus devised by Dr. Vincent.

Orthopedic cases.—I have been much impressed with the opportunity for service offered to an efficient orthopedic surgeon in the prevention of deformities and ankylosis in these military cases. Dr. Osgood has found many cases in which material good has been accomplished by the prevention of threatened deformity in adjacent joints by apparatus, massage, and exercise, and in some cases by secondary operations. I am convinced that the importance of orthopedic surgery in military hospitals will shortly be more widely recognized. A traction table (Maddox, figs. 205 and 206), by which extension during operation, by lever or by screw traction, could be applied to the leg, proved of inestimable value in fresh fractures as well as in secondary operations, such as bone plating.

Sterile supplies.—It is of interest to note that the sterile packages of sponges, gauze pads, etc., put up in Boston in March and packed in tin boxes for transportation, were used without further sterilization, and were apparently perfectly satisfactory. Of a dozen or more operations done under clean conditions, in the same operating room and with the same instruments as were used for septic cases, no failures to obtain first-intention healing occurred.

Dr. Robert B. Osgood, the orthopedic surgeon with the Harvard University unit, contributes the following in a personal communication to the writer:

I have been glad to find that there was an apparent use for orthopedic surgery in a war hospital. The large number of compound fractures and the many injuries to joints demand special forms of fixation. Apparatus of various kinds is therefore constantly necessary.

I have been most favorably impressed with the use of metallic splints, the advantage of which seems to me to be cleanliness, the possibility of using them with slight modifications for different cases, their ease of removal and adjustment. Various forms of splints have been devised and still more may be devised with sufficient adjustment to allow this change from patient to patient (figs. 196–209).

Plaster-of-Paris dressings, with large open spaces bridged by plaster-covered spans of wire or thin band iron, offer what I believe to be the most practicable immediate dressings for septic compound fractures where there is need for constant irrigation and complete fixation. The comfort of the patient has been most satisfactory in these dressings. I have also been most favorably impressed with the overhead extension apparatus in use in Dr. Blake's wards for both arms and legs (figs. 117–121).

Other opportunities for orthopedic endeavor are: (1) The prevention of deformity of joints by maintaining proper alinement of bones. With frequent inspection during the course of the treatment directed toward overcoming the sepsis much may at the same time be done to prevent deformity. (2) The conservation of function of joints is also a matter of great importance and by frequent changing of position wherever possible, or by the maintainance of fixation in the best possible position for function if ankylosis should occur, much may be done to make these individuals able to be early wage earners; (3) as time goes on, I feel perhaps the widest opportunity for orthopedic surgery will be created by the many unfortunate end results which must occur in spite of the best treatment. The time is fast approaching when it will be safe to operate on these cases for the restoration of function, by bone grafts, arthroplastic operations, lengthening of tendons, osteotomies, etc.

PART IV.

GENERAL FIELD CONDITIONS.

In order fully to appreciate all of the conditions under which the allied French, British, and Belgian armies are fighting in the present trench warfare, there must be not only some understanding as to the nature of the battle ground and the circumstances in which the troops live, move, and have their being, but there must also be some interpretation of the strategy involved in the present campaign, if one is to grasp an idea of the situation as a whole. The allied trench line extends from the mouth of the Yser on the English Channel to the slopes of the Jura on the Swiss frontier. Since the trench line is not a straight one, but on the contrary has an exceedingly tortuous outline, it is estimated that the battle front represents a distance of 590 miles. Of this the Belgians hold about 15, the British about 35 and the French about 540 miles. Throughout this vast extent, practically the entire campaign is conducted below the level of the ground both in summer and winter.

The upper western part of the line presents a terrain of low flat country with an insignificant amount of tree growth. Farther to the rear are the low sand dunes, and throughout the general low-lying district are small rivers and canals. Following this line on down, it must be remembered that the present French territory occupied by the Germans represents the rich mineral section of France, and as a consequence there are quite appreciable hills and wooded areas which seem to increase in size as the line swings around toward the southwest. The entire country is generously watered by small rivers and canals. In the Artois region there are some especially large woody areas and hills of varying sizes. In the Champagne and Argonne region there are again large stretches of wooded and hilly country. In the Vosges, the country assumes the character of small mountains, plentifully supplied with low trees, and in Alsace the farther the line extends to the south the larger and more pretentious are the mountain regions which eventually blend with the lower reaches of the Alps.

Not all of the line is held in equal strength, for the reason that there are certain strategic points around which the fighting is of a concentrated and practically continuous character. The space from

the sea to Albert, the neighborhood of Soissons, Rheims, northern Champagne, the Argonne, the Verdun and Nancy circles, and the southern end of the Vosges are sections which require special protection, and in the proximity of which large masses of troops are assembled. Along the remainder of the line the fighting is practically of a stalemate character, owing to the impregnability of both fronts. So close and vigilant are the opposing lines that an attack in force can nearly always be correctly estimated, and in many instances anticipated. As a result the fighting is of an especially intense character and the advances on either side are comparatively insignificant. Notwithstanding this, series after series of attacks have been launched on both sides in the endeavor to outflank a strategic point, and each small advance has always cost the attacking force an enormous number of men in killed and wounded. Trenches can thus be captured by both sides, but each side has its artillery behind, which knows to a centimeter the distance to their own trenches, so that when the latter are captured they can be made practically untenable for the enemy forces.

These facts have undoubtedly had their influence in molding the present strategy on both sides. No longer, except in rare instances, are troops sacrificed in general and open attacks. The fighting all along the line has resolved itself into an effort to outwit the opponent in the art of making war by more subtile means than the mere expenditure of large numbers of men without a commensurate gain. The Germans have met this situation by a steady increase in their heavier artillery and the making use of the newer forms of war waging, such as asphyxiating gas, the projection of burning liquid, and the so-called "poisonous-gas" shell. There are also indications that the Germans are making every effort to establish the superiority of their aeroplanes, and it is said that they contemplate perfecting a monster air plane, which will be heavily armored and carry a crew of 20 men.

The French strategy would seem to be one of gradually wearing down their opponents, principally by the continuously increasing use of their excellent "75" field gun and the increasing activity of their sapping operations. While none of the commoner methods of war making are neglected by either side, it would seem that the present struggle for advantage, as regards actually gaining ground, hinges on the ability of the opposing forces to progressively maintain their superiority along the lines indicated. As a net result, there is an expenditure of high explosive and shell of such enormous proportions as to greatly exceed the calculations of even the most sanguine antebellum experts.

The general increase in the range and intensity of the artillery fire has necessitated a regrouping of hospitals and other sanitary forma-

tions from time to time, with the result that, except in especially selected areas, the fixed type of field hospital is ofttimes from 5 to 8 miles in the rear and the larger type of hospital is still farther back, ranging all the way from 12 to 20 or more miles behind the trenches. The large type of base hospital is usually located in one of the large cities, with good railroad connections, a considerable distance back. Paris, Rouen, Amiens, St. Pol, St. Omer, Boulogne, Dunkirk, Châlons, Bar-le-Duc, Épinal, Nice, and Monte Carlo are all large centers for base-hospital work. In these latter centers, as well as near the front, the military surgeon finds that his work deals with an increasingly large proportion of shell wounds, as compared with other wars, and also the rifle-ball wounds of the head region which are proportionately numerous on account of the fact that in trench fighting the head is more often exposed than the trunk. In addition to this, and on account of the almost immovable character of the trench fighting, the military formations at the front partake of the nature of large stationary encampments behind the firing line, so that the medical officer has also to deal with the problems of hygiene and sanitation incident to the grouping of large masses of troops.

The trench life at best is an exceedingly monotonous one both for officers and men. Except under special circumstances a company of men will occupy a given line of trench for from three to four days, under all weather conditions, at the rate of one man to every square meter of trench space. Behind the immediate firing trench is a series of reserve trenches which are occupied by the company reserves who not only take their regular turn in the firing trench but are held in readiness to repel an attack upon the line. Under these latter conditions there are five men to every square meter of space in the firing trench. Connecting the firing trench with the reserve or supporting trenches is a winding communicating trench (fig. 175) of varying length along which food and the reserve ammunition is carried to the occupants of the firing trench (figs. 172–176).

The average trench is about 7 feet deep by 1 meter wide and is usually surmounted by several rows of sand bags. The sides are usually lined by wooden uprights supporting intertwined crosspieces to prevent the walls of the trench from falling in. The outline of the firing and reserve trenches are the shape of half squares with abrupt turns. There will be about 10 feet of straight trench and then an abrupt turn of 5 feet forward followed by another 10 feet of straight trench and another abrupt turn of 5 feet backward. This arrangement not only gives a greater measure of security to the occupants as regards pieces of flying shell, but admits of an easier defense in case a portion of the trench is captured.

Certain parts of the trench line are more open in character than other parts. At varying intervals the trench is covered over entirely,

and all along the line will be found shallow dugouts in the back wall of the trench which afford some measure of protection in case of rain. Extending back from the reserve trenches for a variable distance is a long, narrow, and winding trench called the *boyau* (fig. 174), which leads to a protected spot in the rear where supplies are located, cooking done, and where troops assemble for entering the trenches. These *boyaux* are from 100 to 200 meters apart all along the line, and it is along these that the wounded walk, crawl, or are carried on stretchers to the "refuge spots," where they are assembled for transportation to the first-aid stations (fig. 177).

Whenever a portion of an enemy's trench is captured a communicating trench is rapidly dug so as to establish a connection with the original firing trench, which latter now becomes one of the reserve trenches. In this manner progress is made for short distances, and in the ebb and flow of trench warfare the battle ground is honeycombed with communicating and cross trenches. So marked is this condition of affairs to the south of Notre Dame de Lorette that a section of the country for many miles is known as the "Labyrinth" on account of the continuous network of intercommunicating trenches.

The opposing trenches average about 50 meters apart and between the two there is a "no man's land," which contains the barbed-wire entanglements and other obstructions, and also the dead bodies of those who have fallen in an assault. The presence of these putrefactive remains is a veritable plague along certain parts of the line and is largely responsible for the prevalence of flies close to the firing line. Sometimes the trenches are only several meters apart, and sometimes, where only a portion of a trench is captured, the opposing forces are only separated by a pile of sand bags. At night the entire area is kept aglow by the continuous use of floating rockets and searchlights. A remarkable feature of trench warfare is that in looking out over the ground through a trench port, or with a periscope, no living thing can be seen for hours at a time, although many thousands of men are facing each other in the underground spaces.

Sometimes, by reason of sapping and other operations, a line of trenches will pass through the middle of a village composed of ruined houses. Every inch of ground is contested, and it is only after an intense artillery fire over a wide section of the enemy trench line that an opposing force ventures to assault. Unless an enemy trench is thoroughly crippled beforehand by artillery fire, an assault is always accompanied by an enormous number of killed and wounded. In case the assault is repulsed, the wounded lie where they fall between the lines until night arrives, which may enable them to crawl back to their trench without being detected. This, of course, causes much additional suffering and the loss of valuable time in the treatment of their wounds.

Those who have fallen in the trenches are immediately replaced from the first or second reserves, and the dead and wounded are removed when a lull in the engagement permits. Telephones are scattered all along the trenches (fig. 173), and the wires pass back, lying on the ground in most instances, to control stations well in the rear of the line. In this manner communication is practically instantaneous throughout the entire area and with other military formations in the rear. The latrines are situated in covered recesses of the ground or in dugouts a short distance to the rear of the trench and connected with the latter by a few meters of narrow trench. Lime and sulphate of iron are plentifully used to cover the excreta, and all forms of trench débris are rigorously collected in large stationary bags and carried back at intervals.

In case of death on the battle field, of which there are a large number, the bodies are carried along the *boyau* to a spot in the immediate rear, where they are buried in narrow trenches. When practicable, the bodies are placed in sacks before burial and religious services are conducted at the time of interment. Scattered throughout the entire area of northern France, and near the firing line especially, are many rows of trenches in which the dead are buried, besides the numerous military graves to be found in local graveyards (figs. 178 and 179).

Some of the German trenches captured by the French have been remarkable for the ingenuity displayed in developing local means of protection. Long galleries, supported by woodwork, have been found to lead down into large dugout spaces, supported by beams and planks, in which a considerable number of men may be comfortably housed. In several instances the elaborateness with which these quarters were fitted up for both officers and men was astounding (fig. 195).

As regards the cooking for the men in the trenches, each company of about a hundred men has its field kitchen, and each man carries with him a tin cup, plate, knife, fork and spoon. For some months after the outbreak of the war the French armies were not supplied with regular field kitchens, but were dependent upon improvised means for cooking the food. At the present time, however, a field kitchen of the same general type as the English kitchen is now in more or less general use by the French. These field kitchens, in some instances augmented by improvised ovens, are situated as close to the entrance of the *boyau* as is compatible with the military situation. From this point food is served up hot to the men in the trenches, and the efficiency of the commissary department has been a large factor in promoting general contentment throughout the French Army (figs. 180–186).

The French ration is an exceedingly liberal one in every way, and no form of wholesome and suitable food is denied the French soldier. (See Appendix No. II.) The men of all ranks and grades are apparently supremely content with this branch of their service. Hot

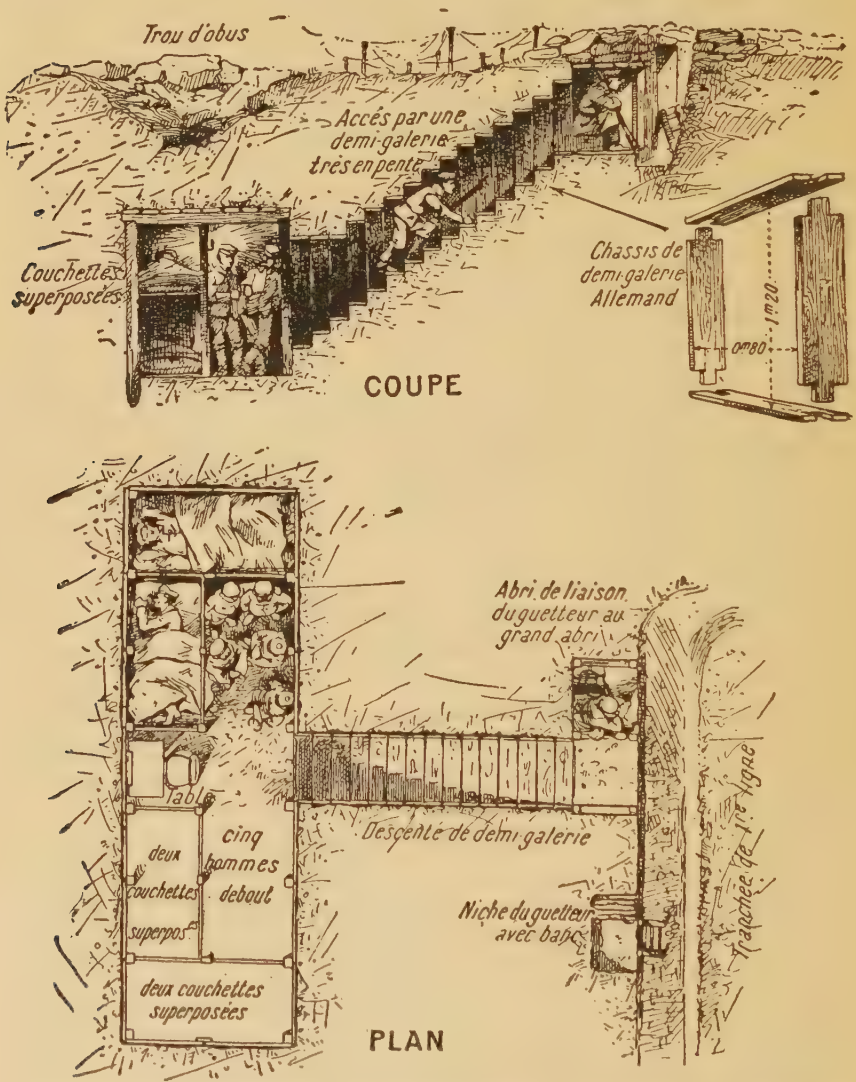


FIG. 195.—Plan of underground living quarters in some of the German trenches captured by the French. (See p. 119.)

coffee and bread are served in the early morning, and hot coffee is also prepared in large quantities and served throughout the day. This latter is rather encouraged by the officers, as it not only guarantees the sterility of the water thus boiled, but reduces the necessity

of drinking unboiled water. The principal meal is in the middle of the day, at which time no means is spared to make this "*dejeuner*" a completely satisfactory repast. In the late afternoon the evening meal is prepared, and in general is of a less substantial character than the midday *dejeuner*. Automobile soup kitchens are used to some extent by the British forces, and they seem to give general satisfaction wherever they have been in operation. As already indicated, each army corps has its large slaughter park, where fresh meat is obtained for daily consumption when so desired. The French are beginning to use imported refrigerated beef, which is gradually supplanting the freshly slaughtered cattle. There are also large army corps and divisional field bakeries, which prepare the loaves of bread for practically all the soldiers at the front.

Whenever it is practicable troops are quartered in villages and towns near the front. Large and small houses are locally requisitioned both for offices and men when the military situation demands it. This is particularly the case with infantry regiments and staff headquarters. On the other hand, large bodies of troops, especially cavalry, artillery, and transports, are located in cantonments at varying distances from the firing line, and in these situations the camps are regulated along the lines familiar to all military men. No large tents are used to attract the attention of aeroplanes and thus draw the fire of the enemy artillery. Small inconspicuous shelter tents are universally used (fig. 180), and whenever it is practicable the protection afforded by groves of trees is made use of, to prevent detection by aeroplanes.

The question of drinking water is a problem of considerable moment for any body of troops in the field. At the beginning of the war the British troops were supplied with a combination field filter and tank, the capacity of the latter being a hundred gallons. So much trouble was experienced with the filters, and so unreliable was their action, that their use has been practically entirely stopped. The hundred-gallon metal tank, mounted on wheels and pushed by two men, containing water to which an active antiseptic has been added, is now the method of supplying drinking water to the troops. The antiseptic used in the water for drinking purposes is 25 grains of sodium hypochlorite to a hundred gallons of water. The water is collected from rivers, pumps, and wells, and allowed to stand overnight after the antiseptic has been added. The British are well supplied with these water carts, and on the whole the system has given general satisfaction. The water carts are supplied with hand pumps for filling the tanks, and the men who collect and distribute the water are under the supervisory control of the medical department.

The French water cart consists of two large barrels, mounted on a pushcart or a one-horse cart. They have the same method of antiseptic sterilization as the English. In addition to this, the British, and to some extent the French, have analyzed the deep wells and local springs, and those which present no evidence of being contaminated by excreta are marked with the legend "For drinking purposes only." At the same time a guard is placed over the well in many instances, to protect it from contamination. These sources of water supply are examined principally for the presence of an excess of chlorids or any of the intestinal bacteria. In case repeated examinations are negative, they are labeled fit to drink without being previously boiled. In towns and villages the local water supply is used under the strict surveillance of the medical department, and in many instances it is not allowed to be used unless previously boiled or antiseptically treated.

With the exception of light wines and a very light French beer, no alcoholic beverages are allowed to be sold in any town or section near the front. The order prohibiting the presence of alcoholic drinks at the front was at first considered a great hardship, but as time went on the wisdom of this order was fully appreciated, and it is believed by many to have resulted in a marked general improvement in the physical condition of the men who are kept in the fighting zone.

Next to drinking purposes a liberal water supply is most beneficial for keeping the body and clothes clean. Wise provision has been made all along the line to enable the troops who are not actually in the trenches to obtain a daily bath. In some instances houses have been supplied with large, flat wooden tubs capable of conveniently holding two men. In other instances improvised shower baths are used (fig. 193), and in addition the rivers and canals are marked off at certain points where men are allowed to bathe and wash their clothes *ad libitum*. The question of bathing and general cleanliness is, of course, a most important one, as aside from the hygienic principle involved it has a general exhilarating effect on the men who have spent days and nights in the trenches.

The question of flies at the front (figs. 188–192) has become a serious problem, for not only are they disease producing and generally annoying to human beings but certain species are especially active around domestic animals, notably the horse. The common house fly (*Musca domestica*) ranks first among these pests. The others which are also found at the front in considerable numbers are the urinal fly (*Scatella urinaria*), the blue (*Calliphora vomitoria*) and green (*Lucilia cæsar*) meat flies, and the flat horsefly (*Hippobosca equi*).

The habits of these insects are not all alike, but the life cycle of each is very much the same. The average life of a fly is about one year, and toward the end of summer the females lay their eggs, 60 or 70 in number and cylindrical in form. The fly picks out unclean, damp places to deposit its eggs, such as manure piles, garbage of all kinds, or any place where there is rotting animal or vegetable matter with a moderate amount of humidity. The eggs develop very quickly, the larvæ make their appearance, the short pupa stage occurs, followed by the winged insect. During this period the larvæ feed voraciously upon the moist decaying material, and it is at this time that its destruction can be accomplished most easily.

The urinal fly abounds in the neighborhood of badly kept urinals or where urine is habitually deposited. It seldom flies, except in masses, and abhors dryness and sunlight. It thrives on urine, in close proximity to which it deposits its eggs. The flat horsefly is an habitué of places frequented by horses and cows. It derives its food from decaying animal matter and lays its eggs in manure piles. It is chiefly annoying on account of its spiderlike characteristics in crawling over and clinging to horses and cattle. The blue and green meat flies scent from afar either cadavers or tainted meat upon which they actively feed and lay large numbers of eggs; these quickly develop into the "maggots" familiar to all.

At the front, where large numbers of horses and cattle are present, it is extremely difficult to prevent the accumulations of manure on account of the military situation. A great deal has been accomplished, however, by the systematic collection and burning of all forms of manure, garbage, and refuse. Improvised incinerators are used for this purpose, situated well back so as not to draw the fire of the enemy by attracting attention to the smoke. Practically nothing can be done for the decaying cadavers which litter the ground between the opposing trenches. No opportunity to remove these remains is permitted by either side, and as a consequence they attract the presence of large numbers of flies.

The best means of getting rid of the fly is to prevent its breeding. This is accomplished either by preventing uncovered and decaying animal or vegetable accumulations, or by soaking such accumulations with a solution of an active antiseptic. In the first instance, all forms of manure or excrement should be promptly removed and either burned or covered in such a manner that the flies can not reach it. In like manner all forms of garbage should be collected in covered pails or barrels and eventually burned. The stables where horses or cattle are kept should be darkened, all forms of refuse promptly collected and destroyed, and the occurrence of damp places prevented by exposure to sunlight or by covering over with

small gravel. All urinals should be well lighted, ventilated, and supplied with an automatic antiseptic drip (creosote compound).

In case the manure is to be used by the horticulturists it is difficult to prevent its becoming a breeding center for flies unless antiseptically treated. Most active antiseptics are toxic to plant life, and hence a number of valuable antiseptics can not be used in sufficient strength to kill the larvæ. One of the best and most economical preparations to use on manure is a 10 per cent solution of sulphate of iron. This will not only promptly kill the larvæ and deter flies from attempting to lay their eggs, but it will not destroy plant life.

Despite all that has been done, the trenches are infested by swarms of flies, which are temporarily attracted from other places by the presence of food. There is no doubt that these flies, which swarm over the food while it is being eaten, are accountable for the occurrence of typhoid and paratyphoid fevers. There is also evidence to show that the cadaveric contamination of the food by the flies is responsible for the more or less severe gastro-intestinal disorders which occur from time to time. In addition to this their presence is extremely annoying to those who have to occupy the trenches for many hours at a time.

The mosquito does not seem to be the pest at the front that would be supposed, judging from the general conditions which are favorable to its propagation. Small rivers and canals are abundant, and rain water collects in the numerous trenches and other depressions in the ground. While the trenches are kept fairly free from water by means of hand pumps, there are many small collections of water which remain in other places to form potential breeding places. Nevertheless, only a comparatively small number of stegomyia are to be found, and rarely ever in such numbers as to be annoying. In the southern part of France the anopheles makes its home and apparently does not migrate. Except for an occasional recurrent attack of malaria in individuals who formerly contracted the disease while living in the south, there is no evidence of any ill effects from the presence of the few mosquitoes at the front.

In considering the general health of all the soldiers actively engaged in field operations it is remarkable how few, in comparison to the number involved, are incapacitated on account of disease. At the beginning of the war a certain number of insane cases developed, apparently as the result of the harassing conditions incident to trench warfare. As France and England have now been under arms for over a year this type of illness has been largely eliminated by the early removal of all weaklings from the ranks. The general open-air existence has not only kept the average man in good health, but it has been a distinct benefit in creating a more robust appearance

in the great majority of the soldiers. Influenza has made its appearance in mild epidemic form, principally among the older men, during periods of damp cold. Articular rheumatism, while manifesting itself at times, has not resulted in any conspicuous number of cases. Myalgia seems to be more prevalent, although of short duration. Very few cases of anything resembling dysentery have occurred although there have been at times quite a number of unclassified intestinal disorders. The prevalence of typhoid and paratyphoid fevers has already been discussed and attention drawn to various aspects of these diseases. Probably on account of the general open-air housing of all troops there has been no manifestation of epidemic cerebrospinal fever. Pneumonia of both types has occurred at times, but a remarkably few number of cases are to be seen in the medical wards of hospitals. One very striking fact is the insignificant number of cases of appendicitis during this war. In view of the very large number of young men in the ranks between the ages of 20 and 30 it would be reasonable to expect a fairly good percentage of these cases. On the contrary, it can be said to be of rare occurrence, although the well-known predisposing factors, early adult life and increased activity, are in favor of producing this disease.

There is comparatively little marching done by the troops as a whole, due to the fact that the remarkable development of the usefulness of the automobile during this war has made the necessary and quick transfer of troops from one part of the line to the other a comparatively easy matter. Large public conveyances of all kinds, as well as an enormous number of motor lorries, are now used to convey large or small bodies of troops from one part of the line to the other (fig. 187). For this reason there have been comparatively few complaints as regards sore or incapacitated feet from the effects of marching.

No report of the general allied war situation in France would be complete without some reference to the one man who is responsible for the conduct of the entire campaign. Joseph Jacques Joffre (fig. 194), the generalissimo of the allied front, a man of the people, whose father was a cooper, typifies probably more than any one man in France to-day the spirit with which the nation has assumed its obligations as regards the factors leading up to and beyond the opening of the present European conflict. Unassuming and excessively modest, he has never laid claim to being a military genius; and even those who know him best, and who are in a sense his sponsors, do not endow him with any superhuman traits, nor do they attribute to him any of those scintillating qualities which have in times past been associated with the leadership of large armies.

Of his steadfast courage, unswerving determination, and truly great capacity as an organizer his country has had abundant proof

both before and since the present conflict. Throughout his entire career the official record shows him to be a man who has accomplished by plodding and painstaking endeavor whatever mission has fallen to his lot to perform. His attitude toward those below him has been rather as a father to his children than as an autocratic general to his men. He has never been of the slave-driving type in directing his plans, but attains his results with the quiet assumption of leadership which expects every man to do his duty.

The most striking characteristic of Gen. Joffre is his uncompromising intolerance of inefficiency. While making allowance for human frailties, he has never condoned a failure on the part of his subordinates in carrying out their allotted task. His honesty of purpose in this respect has never been questioned, even by the many general and other commanding officers whom he has retired since the war began. He insists on his supreme authority as regards every detail pertaining to the "zone of the armies" and will brook no interference from any quarter in connection with his decisions on all matters relating to discipline. Although due regard is given to the suggestions of others, and though his efforts are largely influenced by the policy of the Government as represented by the ministers, yet he maintains that he alone is to decide upon the manner and means of carrying out whatever has been planned. More than once has he indicated his willingness to relinquish the great authority vested in him unless upheld and unless he had the full confidence of the Government. His generals have the greatest latitude as regards accomplishing whatever task he allots, and while specific orders deal with the situation as a whole, the discretion of a commanding officer is relied upon to meet any unexpected contingency. All that the generalissimo expects is that nothing has been neglected nor overlooked to make his plan a complete success.

Gen. Joffre has always exhibited methodical care in everything that he has undertaken. He rises early, works steadily during the hours that he has allotted himself, but he is particularly careful as regards his health. His meal times, his sleeping hours, and his exercise periods he regards as peculiarly his own, and unless a real emergency is encountered by his subordinates, he is never disturbed during these stated periods. So well has he ordered his life and cultivated his resources that he finds himself to-day in vigorous possession of the strength of mind and body which is all-important as regards great and continuous responsibilities. There is not a soldier in France who has not a correct estimate of Gen. Joffre, and this supreme confidence in him is only surpassed by the sincere affection in which he is held by every man in the army.

APPENDIX NO. I.

The following is a paper read before the French Academy by H. D. Dakin, Ph. D., the title of which is: "On certain active antiseptic substances suitable for the treatment of infected wounds."

The relatively low germicidal action of the more commonly employed antiseptics is, as is well known, still further reduced when these antiseptics act in the presence of serum or other protein substances. It is probable that the killing of micro-organisms by antiseptics is largely a chemical reaction between the antiseptic and the protein substances of the micro-organisms. Since the practical employment of antiseptics invariably occurs in the presence of large quantities of protein substances other than those of bacterial origin, it is probably true that no relatively simple chemical antiseptic can be found which will react solely with the micro-organisms and not with the adjacent protein substances. In seeking an efficient antiseptic for use in infected wounds it would appear that the following points, among others, are of the first importance:

(*a*) To employ substances of such high germicidal activity that even when the activity is reduced by the presence of serum or other protein powerful antiseptic action may still persist. Or, in other words, to employ substances which give actively antiseptic substances after combination with proteins. The complete failure of mercuric chlorid to respond to this demand may be cited. (*b*) It would appear probable that soluble salts, nonprecipitable by proteins, which may penetrate and be absorbed to some extent, are preferable to substances of other type in which the possibility of absorption and penetration are slight. (*c*) The toxicity and capacity for inducing local irritation of an antiseptic should be as low as possible in proportion to its bacterial activity in order to permit of the local employment of a sufficiently large quantity of the antiseptic without unfavorable results. It is clear that if germicidal action is essentially a chemical reaction in which other proteins than those of bacterial origin may take part, it is most important that the active mass of antiseptic should be as large as possible.

Among the antiseptics which have already been considered in connection with the treatment of infected wounds the hypochlorites most nearly respond to the criteria above set forth. Unfortunately, however, the hypochlorites of commerce are of very inconstant composition and generally contain either free alkali or free chlorin. Such substances are irritating and when used in moderate concentration may produce very unfavorable results. It appeared desirable to try and find a mode of preparing a solution of a hypochlorite of constant composition which would show high bactericidal activity and low toxic or irritating qualities. The following method has proved successful:

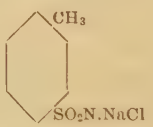
Two hundred grains of bleaching powder are added to 10 liters of water, in which 140 grains of dry carbonate of sodium have been dissolved. The mixture is well shaken, and after half an hour the clear liquid is siphoned off from the precipitate of calcium carbonate and filtered through cotton. To the clear

filtrate enough solid boric acid is added to render the liquid *acid* with an aqueous suspension of phenolphthalein, but *alkaline* to tournesal. About 25 to 30 grains may be required. The exact amount of boric acid to be added may be conveniently determined by the titration of 10 c. c. of the alkaline hypochlorite solution with a solution of boric acid of known strength (31 grains per liter). In preparing a dilute solution of hypochlorite as the above, which will contain about 0.5 per cent NaClO, an excess of boric acid is unobjectionable, but in the case of stronger solutions an excess must be avoided.

A solution prepared as above described containing 0.5 per cent NaClO, kills staphylococci in 2 hours when diluted to a concentration of less than 1 to 500,000 NaClO, while in the presence of blood serum the necessary concentration of NaClO is between 1 to 1,000 and 1 to 2,500. Such a solution has proved to be a useful antiseptic in the treatment of infected wounds when properly applied by methods which will be described later by Dr. Carrel. Wounds may be constantly irrigated for many days without producing noticeable irritation, and bacteriological examinations of the wound secretions demonstrate a vigorous antiseptic action. In addition to its antiseptic action, the solution exhibits marked capacity for dissolving necrotic tissue and has some hemostatic action. From a practical standpoint, the property of assisting the dissolution of necrotic tissue is important.

It is probable that the antiseptic action of hypochlorites is due to their containing chlorin in an active state which may replace hydrogen atoms attached to nitrogen in the (NH) groups present in proteins, forming substances of the group known as chloramins. It was of interest to investigate substances of this type, and with the cooperation of Prof. J. B. Cohen, of the University of Leeds, a large number of these derivatives have been prepared and tested. The most encouraging results have been obtained with the sodium salts of aromatic sulphochloramids, particularly the benzene and paratoluene derivative.

Benzene sodium sulphochloramid.



Paratoluene sodium sulphochloramid.

These substances are active antiseptics, practically nontoxic, and their aqueous solutions can be employed for the antiseptic treatment of wounds in a far higher concentration than is possible with the hypochlorites; but, on the other hand, as would be expected from their structure, the chlorin being already bound to nitrogen, they show little capacity for assisting in the dissolution of necrotic tissue.

Paratoluene sodium sulphochloramid kills *B. perfringens* in water acting for 2 hours at a concentration of less than 1 to 10,000,000, while in the presence of serum the concentration necessary is between 1 to 2,500 and 1 to 5,000. With staphylococci the concentration is about 1 to 1,000,000 in water and 1 to 2,000 in serum, while *pyocyaneus* requires about 1 to 1,000,000 in water and 1 to 1,500 in serum for complete sterilization in 2 hours.

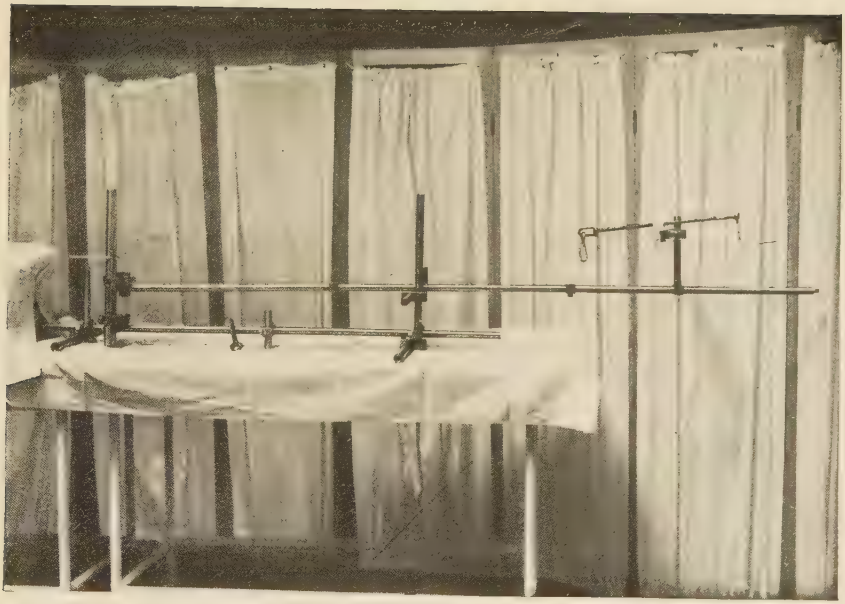


Fig. 196.—The Maddox table for the application of extension on the lower extremity while putting on plaster dressings.

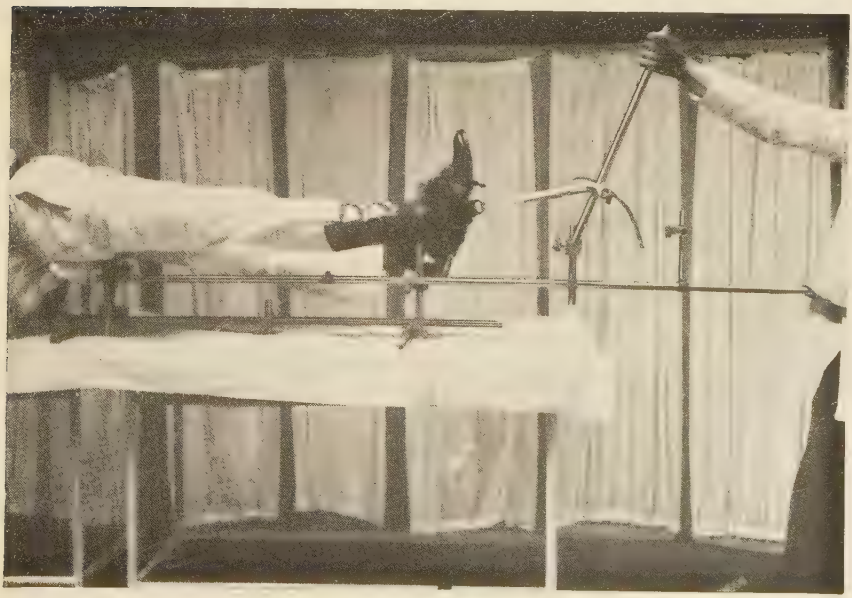


Fig. 197.—Same as figure 196, showing the application of extension during an operation.

Fig. 198.—(1) Light wire splint for forearm or hand; (2) light adjustable aluminum section for splint material; (3) aluminum splint for elbow, forearm, and hand.

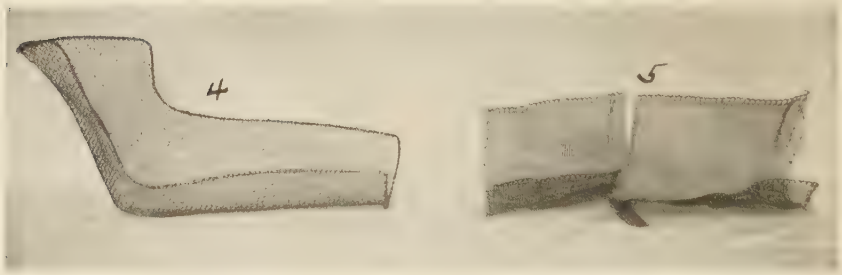


Fig. 199.—(4) Light wire splint for forearm or elbow; (5) light adjustable wire sections for splint material.

Fig. 200.—Thomas ambulant leg splint.

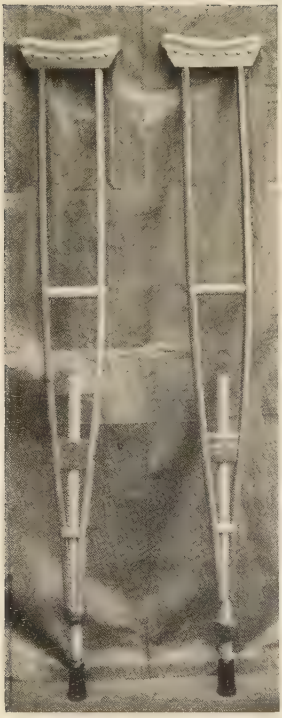


Fig. 201.—Adjustable German crutches used by a German prisoner.

Fig. 202.—Temporary thigh or leg field splint with anklet for securing extension.

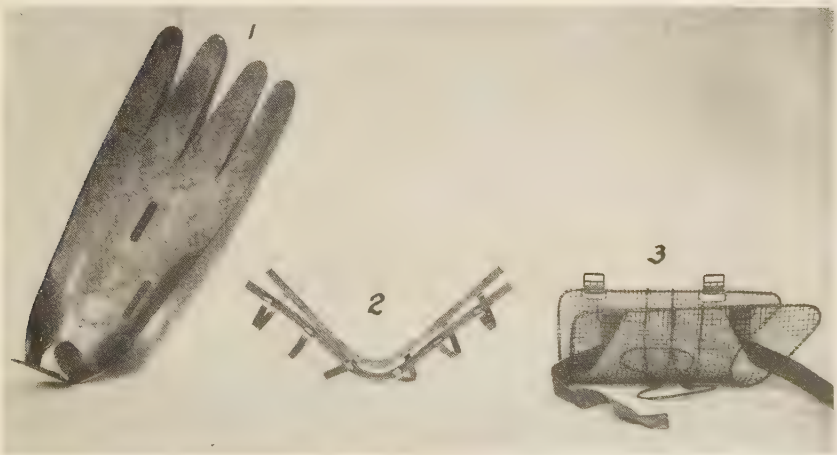


Fig. 203.—(1) Aluminum hand splint; (2) adjustable aluminum elbow, arm, or forearm splint; (3) light wire splint for thigh or arm.

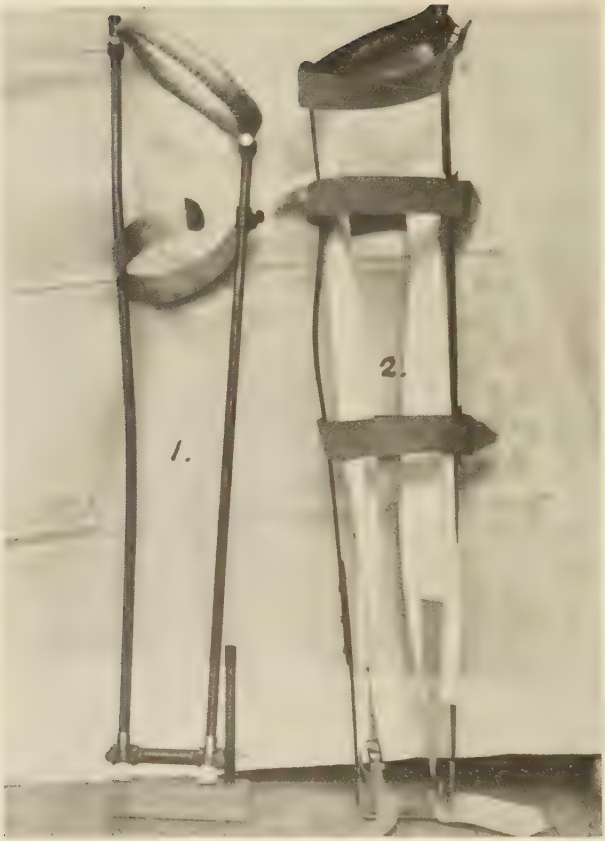


Fig. 204.—(1) Thomas ambulant splint for leg or thigh; (2) old model Blake splint with extension straps.

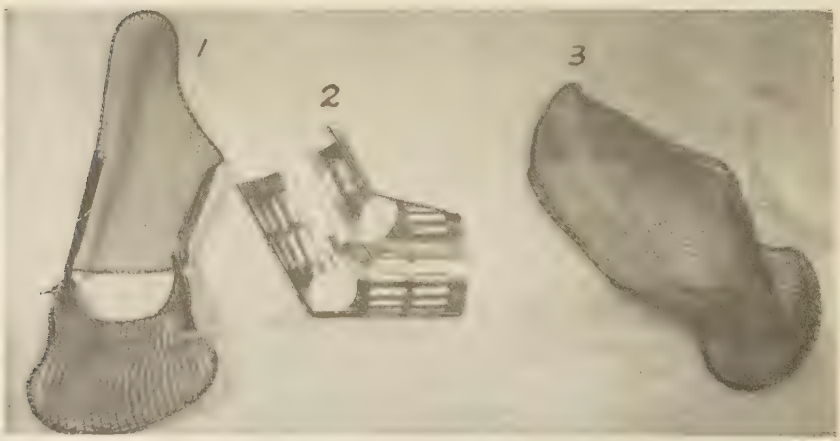


Fig. 205.—(1) Hinged wire elbow splint; (2) adjustable aluminum elbow splint; (3) wire elbow splint.

Fig. 206.— (1) Extemporized wire splint for thigh; (2) aluminum leg splint.

Fig. 207.—(1) Light wire leg splint; (2) aluminum leg splint; (3) light wire leg splint.

Fig. 208.—(1) Light aluminum sections for lateral fixation; (2) aluminum elbow splint; (3) aluminum elbow, forearm, and hand splint.

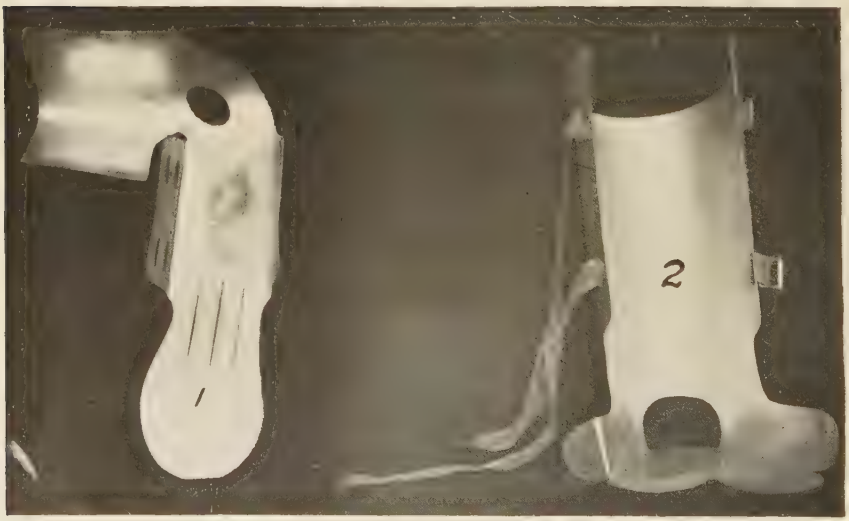


Fig. 209.—(1) Aluminum splint (same as figure 208 (3)), another view; (2) aluminum leg splint.

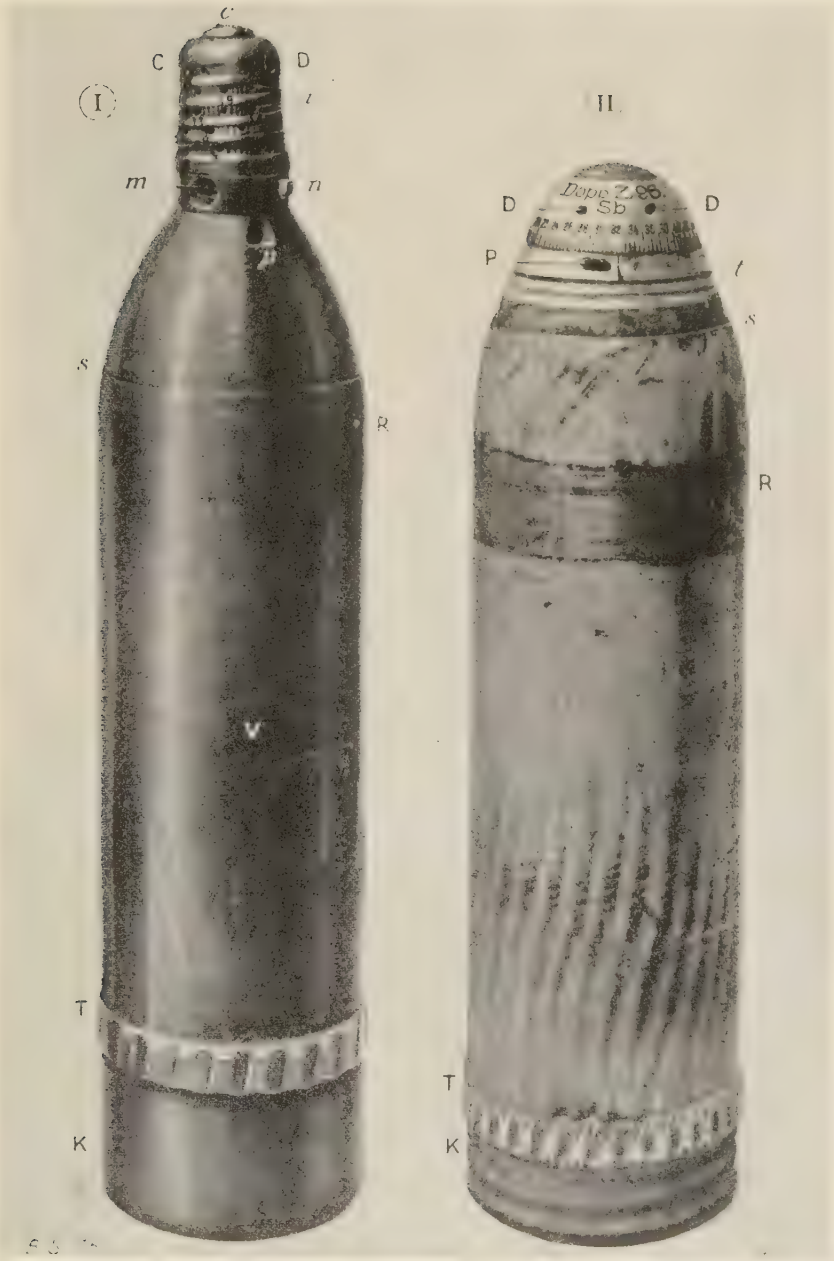


Fig. 210.—For description see text, page 137.

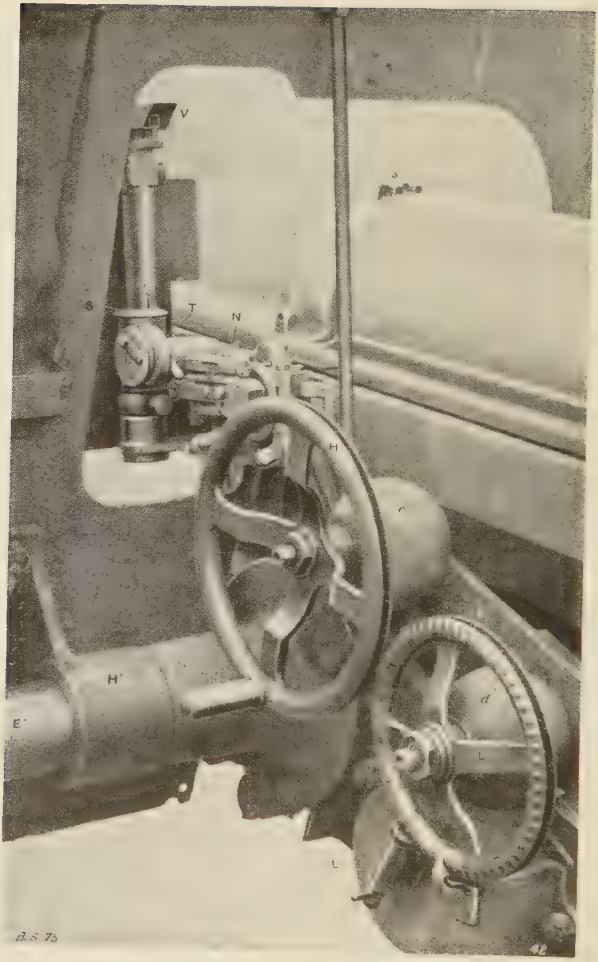


Fig. 211.—For description see text, page 138.

Fig. 212.—For description see text, page 139.

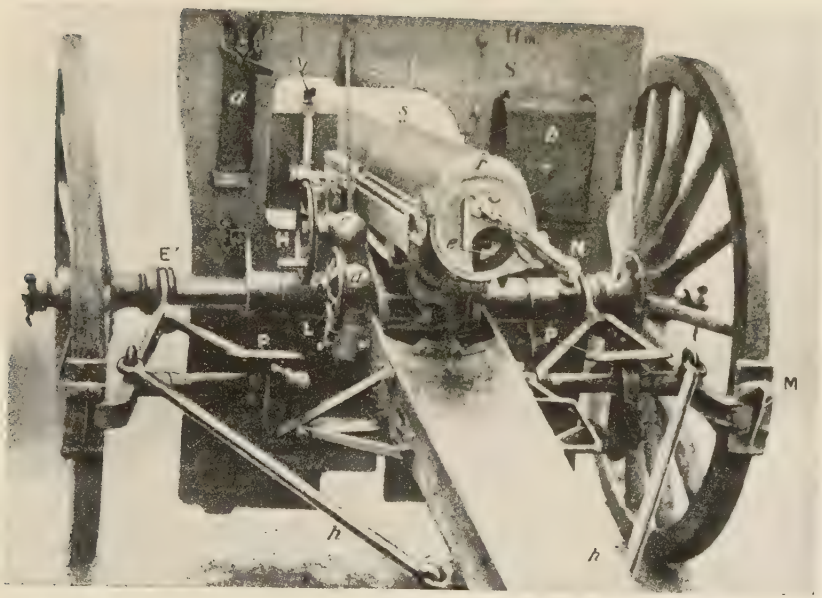


Fig. 213.—For description see text, page 139.

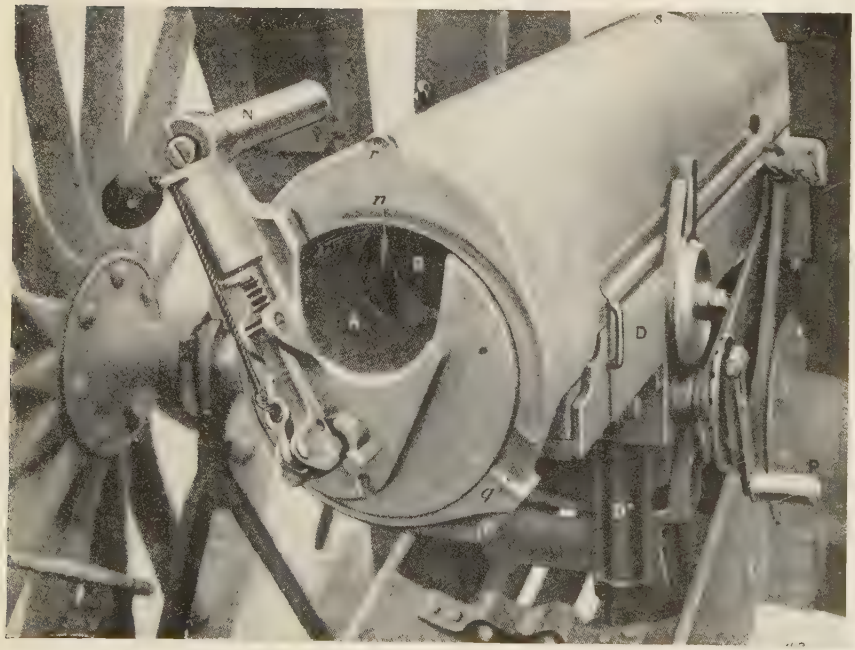


Fig. 214.—For description see text, page 139.

APPENDIX NO. II.

THE FRENCH ARMY RATION.

There are three rations authorized in the French Army: The reserve ration, the strong ration, and the normal ration. (For components, additions, and substitutive equivalents see Appendix at the end of this report.)

There are also five different forage rations, each having a maximum and minimum oats allowance.

The greatest possible latitude is allowed in making substitutions with supplies procured by exploiting the local resources. This authority is vested in all division generals and subordinate commanders. The substitutive articles and quantities of each authorized to be issued in lieu of a ration component are given further on. The list given in this appendix was that in force prior to the commencement of the present war, and it has been greatly augmented since. There is practically no limit to the articles that may be substituted by higher commanders as long as common sense is displayed both in the dietic properties of the food and the cost to the Government. This matter is regulated in orders issued by army and corps commanders. In these orders the prices of different foodstuffs are fixed, and the farmer or merchant in the theater of operations is given the chance to sell these supplies at or below these figures; otherwise the supplies are formally requisitioned and paid for at the rate stated in the order. The same principle holds with reference to substitutions in the forage rations.

The "Extraordinary supplements authorized" (see Appendix) can only be authorized by army and corps commanders or by commanders of independent forces. In this case the supplies must be furnished from the chain of supplies moving from the base depot forward, and these are the only commanders who are in a position to make the arrangements to meet this situation. In the first instance it must be remembered that the substitutes authorized are obtained locally, and therefore no additional drain is made on the regular chain of supplies coming forward, previously referred to. This principle in the French system is based on "the automatic food supply." Under this system, one day's complete food supply for the entire army goes forward daily from the regulating station to the railhead, and from that point forward until it arrives at the ration wagon of the organization. If the organization has procured a substitute for one of the component articles locally, it follows that it will not need certain articles carried by the train and about to be issued. It therefore does not draw these supplies. The latter train has then a surplus, and when it is subsequently refilled at the railhead, it leaves undrawn at that point a corresponding quantity. Similarly, the railroad train has a surplus, which it carries back to the regulating station, where the general readjustment is made.

In addition to the ration, commanders of organizations and detachments are given a daily allowance of 20 centimes (4 cents) per day per man, with which they are authorized to purchase locally additional food supplies. This fund corresponds to the United States Army company fund.

In times of peace, in garrison, the French ration is largely commuted at prices fixed by corps commanders and based on the local market prices. In time of war this system is not used except in the case of very small detachments (principally cavalry), chauffeurs, and other individuals who can not be conveniently rationed by organizations. In the latter case the commutation rate is fixed in army orders.

In the positions at present occupied by the French Army, which have not changed materially for some months, it is comparatively easy to supply the men and animals. The utmost advantage has been taken of the elasticity allowed for substitutions and additions to the ration. The entire French Army in the zone of the armies has had a most trying time during the winter, due to cold and the water in the trenches.

Roughly speaking, from one-third to one-half of the time they have been in the first-line trenches; the remainder of the time they have spent either in supporting trenches or in towns more or less subjected to German artillery fire. In the first-line trenches the quarters or dugout shelters of the men are heated with coke or charcoal fires, which give out no smoke. Food is cooked in large kettles and field kitchens behind the trenches and is subsequently taken out to the front-line trenches and distributed. The men eat a hot, cooked meal that night and save the rest of the food for the next day's lunch, when it is heated before eating over the fires in the dugout shelters before mentioned.

Men and officers say they have all fared better under these trying conditions than they usually fare in barracks in peace time. The result of this good feeding is apparent in the physical condition of the men and in the astonishingly low sick reports. The Government and the army commanders have realized the importance of keeping the men fit during all this period of more or less enforced stationary siege fighting. They have thoroughly realized that it is very poor economy to restrict the food of the men when there is no necessity for it, as there may be later on in the campaign if a forward movement is undertaken in a country with all the railroads destroyed.

The reserve ration is the ration that is carried on the man or horse. Within the last few years an effort has been made to reduce the load carried by the man, and a portion of this reserve ration is now carried in the combat train.

The reserve ration carried by divisional cavalry and that carried by all elements of a cavalry division is one day's hard bread, three days' coffee and sugar, and one day's canned meat and *potage salé*. The total gross weight of these components of the reserve ration is 2.53 pounds. In addition, one day's brandy per man and 4.4 pounds of oats per horse are also carried.

The reserve ration carried by all other troops and elements of the army is a straight two days' ration, except that only one day's brandy is included. One day's oats is also carried.

One half of this reserve ration is carried on the man or horse, the other half plus the brandy is carried on the baggage wagon attached to the combat train. The reduced ration of oats is carried on the cavalry horse (it is only one feed), while the one day's oats for the other troops is carried in part on the mounts and in part on the wagons.

The reserve ration is, in general, only consumed when so ordered by corps or division commanders, when contact can not be made with the ration wagons. In rare cases, when there are no other means of feeding the men, organization commanders may, on their own responsibility, authorize its consumption. In this latter case a full written explanation of the reason must be submitted.

The strong ration is that usually supplied daily in the field to French troops, and it is on the weight of this ration that transportation allowances are based. It is realized by the French that troops in the field are subjected to much more severe physical effort than troops in garrison. To provide this additional energy, additional food is given in the shape of a strong or increased ration.

The normal ration is that prescribed for troops in time of peace in bar racks, or in time of war when comfortably quartered, out of the presence of the enemy.

As before explained, the strong ration is very elastic and supple. Almost any condition can be met without the fear of violating regulations.

In principle the French soldier (not including the cavalryman) receives each night from the ration wagon the supplies that he is to consume at his two meals the following day. (It will be remembered that Frenchmen only eat two meals per day, with the exception of some coffee early in the morning, one in the morning before noon and one in the late afternoon.) These supplies he carries in a light canvas bag (*musette*), swung with a loop on his right shoulder. At the same time he receives one day's ration of fresh meat, which is issued him from the *voiture de viande* (meat wagon) which is attached to the combat train. One-half of this is eaten that night and one-half, after cooking, is put in his *musette* to be eaten cold the next noon. We thus find that every morning, upon leaving camp or bivouac, the French soldier has with him (independently of the reserve ration), one day's supply of field bread, one-half day's supply of fresh meat (cooked) one day's supply of dried vegetables to be cooked for the evening meal, one day's supply of salt, and one day's coffee and sugar, with the exception that some of this coffee and sugar is used in the morning.

As before explained, these supplies may be varied by substitutions and additional purchases made from the 4 cents a day allowed to each man over and above the ration. In addition to the above, one day's oats is available for each horse.

In the cavalry every effort is made to reduce the weight carried by the horse, and, in consequence, theoretically their rations are issued to them every evening before supper. The evening meal and a cooked cold luncheon for the next day are prepared the same evening. We therefore find that in the morning, upon leaving camp, the cavalry has, in addition to its reserve ration, only the food necessary for one meal. Under this system it may be readily seen that the evening meal of the regular rations (the strong ration) is dependent upon the ration wagons making contact with the troops in time for the preparation of the evening meal. It will, of course, be remembered that so long as the cavalry is inactive it will probably be kept near a place where rations can be readily supplied, and, if active, it will be in a better position than other troops to secure its supply locally.

The same system is used with reference to the oats issued from the ration wagons for the horses, though in this latter case the one feed previously referred to, carried as the reserve forage ration, is issued immediately upon arrival in camp or bivouac and is replaced when the wagon arrives.

This system of issuing rations is called by the French "*au cheval.*" Previously it had been used with all troops, and it is still used by such of the French organizations as are equipped with rolling kitchens. However, with infantry troops not equipped with rolling kitchens, it has been found not to be practicable, owing to the delay of the ration wagons in making contact with the troops.

TRAINS.

Each organization, including division and corps headquarters, has a combat and a regimental train (field train). To the corps is also attached a corps supply train and a corps meat train (autotrucks). In addition, there is a corps cattle park attached to the corps.

The combat train is divided into two echelons, called the first and second, respectively. For purpose of clearness, a combat train of an infantry regiment, as laid down in the French regulations, will be explained. The strength of a French infantry regiment is 3,000 men, and this strength is maintained by reserves sent forward to replace all losses. The same principles apply to the other combat trains, though they differ considerably in the different arms.

The first echelon remains with or in the immediate rear of the organization to which it belongs when on the march or during combat. It includes one-horse sanitary carts carrying equipment for first-aid stations, two-horse carts for ammunition for companies, four-horse wagons or caissons for machine-gun ammunition, and two-horse carts carrying entrenching and other tools.

The second echelon, while on the march out of the presence of the enemy, usually marches with the first echelon. When contact with the enemy is expected, it is detached and grouped with other second echelon combat trains, either in brigade or division groups, depending upon the orders issued. During this period of grouping its movements are controlled by the headquarters ordering the grouping. The grouped second echelons are usually held well in the rear under cover and "out of the road." This echelon includes two-horse wagons (on these wagons are also carried a portion of the reserve rations previously referred to), a two-horse forage wagon, and 3 two-horse meat wagons (one per battalion). In addition the regulations provide that the two-horse rolling kitchen (when organizations are equipped with the same) will form part of the second echelon of the combat train.

The regimental train (*train régimentaire*) corresponds exactly to the ration section of the field train of the United States Army. All field units, including the different headquarters and trains, with the exception of the corps supply train, have a regimental train. The regimental trains of all units, except that of the cavalry division, carry the following supplies (on the basis of the strong ration), viz:

Bread (generally field bread)	days	2
Salt	do	2
Lard	do	2
Rice or dried vegetables (1 day of each)	do	2
Canned meat with *potage salé*	day	1
Coffee (1 day's supply is on the basis of the reserve ration)	days	2
Sugar (1 day's supply is on the basis of the reserve ration)	do	2
Brandy	day	1
Oats	days	2

The regimental trains of the cavalry divisions carry the following supplies (on the basis of the strong ration):

Field bread	day	1
Salt	do	1
Canned meat with *potage salé*	do	1
Coffee (on the basis of the reserve ration)	do	1
Sugar (on the basis of the reserve ration)	do	1
Brandy	do	1
Oats	do	1

The foregoing figures are based on the load at the time the troops start out, which of course changes as soon as issues begin. It is not safe, therefore, to count on having on hand more than one day's supply.

The regimental trains of all units are usually kept grouped at all times when the troops are on field service. This grouping is almost invariably by divisions, and while grouped this train is under the orders of a single officer, who moves the grouped trains in accordance with orders received from division headquarters. When the troops have halted, orders are issued from division headquarters to send forward one day's supply of food, and men from the different organizations go to the grouped trains and conduct the loaded vehicles to the troops. The issues are made and the empty vehicles are at once sent back and grouped again. If any supplies are obtainable locally and their substitution is desired by the troops in place of what is carried in the wagons, the substitution is made and the corresponding ration articles remain unissued in the wagon.

From time to time the division headquarters is notified of the point selected as the "distributing point," and it in turn notifies the officer in command of the grouped train, who sends the empty wagons to that point at the hour fixed for reloading. As soon as they are reloaded they rejoin the grouped train.

The system of fresh-meat supply in the French Army has been materially changed in recent years. Each division used to have a cattle park, where the cattle were butchered and the dressed meat sent forward in wagons, where their loads were transferred to the meat wagons of the second echelon of the combat train. This was found to be very cumbersome. To-day the division cattle park has been suppressed and replaced by the corps cattle park, where the slaughtering is now done. The fresh meat is to-day loaded in the army corps meat train, which is pushed forward close to the point where the grouped second echelon of the combat train is halted, and the organization meat wagons are filled at these places.

The meat supply of the French soldier has always been a most difficult question, owing to the national prejudice in France against refrigerated meat. This prejudice is somewhat on the wane to-day, owing to a lack of cattle in France, and a great quantity of Argentine beef is now being received. They are having some trouble in handling this beef, due to the fact that refrigerator railroad cars are to all intents and purposes hardly known in France, and to the further fact that there are not many cold-storage plants for the reception of the meat. Of course most of the big cities have these plants, but none are found in the small towns as in America. To-day an effort is being made to use the refrigerated meat in the zone of the interior and to reserve so far as possible the live cattle for use in the zone of the armies.

With a view to the simplification of the entire fresh-meat supply, a number of different methods have been and are being tried in France. One method

by which the fresh meat was thoroughly salted (*viande demi-salé*) was tried out, but has been practically abandoned to-day. This system had the advantage that the meat could be slaughtered and treated well to the rear, even back in the zone of the interior, and could be sent forward in the regular trains through the regulating station. If successful, it would have done away with the corps cattle park and the corps meat train. The disadvantage was due to the fact that, while the center of the meat so treated was perfectly good, the exterior surface became discolored and somewhat decayed and smelly.

To-day they are trying out a new scheme by which the fresh meat is first cooked and boned, then wrapped in cheesecloth and the moisture pressed out. If this is successful, it will greatly simplify the fresh-meat difficulty, particularly if the war lasts long, and if refrigerated beef has to be resorted to entirely. If this meat after cooking and treatment in the manner indicated will stand for five or six days, it will be successful.

The Frenchman does not like our cured bacon nor does he like canned meats. His wants, therefore, so far as meat is concerned, are much more difficult to meet than is the case with our troops.

The autotruck made it possible for the French to do away with the division cattle park and to do their slaughtering and delivering at the corps cattle park well in the rear. All the autobuses in Paris were requisitioned, and these are to-day distributed between the different army corps and form the corps meat train. These autobuses have somewhat the appearance of one of our street cars in America. They have a platform on the rear and windows on either side. The glass in the windows has been removed and replaced by fly screens with cotton bunting behind to keep out the dust. The meat is suspended from hooks placed on the rods running along the ceiling of the car, which previously furnished the supports for the hand straps. Each autobus will carry approximately 4,000 pounds of beef. Approximately 15 of these autobuses are assigned to each corps. The maximum distance to the front which they are able to supply is 75 kilometers. It therefore follows that the corps cattle park can be at this maximum distance to the rear.

Corps cattle parks are usually situated near the railroad, where cattle on the hoof are delivered by train. Their equipment is the simplest possible, notwithstanding the fact that the daily requirements of a corps necessitate the slaughter of from 100 to 120 head of cattle a day. Usually barns and stables are used for this purpose. The equipment in general consists of large wooden tripods or derricks, about 8 feet high. After the animal has been hit on the head he is pulled up by the hind legs, the throat arteries cut, and the meat dressed. The hides are all most carefully saved and shipped back to the rear. The meat when cut up is at once loaded into the autobus, where it cools. A veterinary surgeon is always present during the slaughtering to pass on the quality of the meat.

Slaughtering is usually done in the late afternoon, the autobuses or corps meat train being sent forward the following morning to make contact with the organization meat wagons (attached to the second echelon of the combat train). The meat is then transferred and the autobuses in time return to receive their new loads during the slaughtering in the late afternoon. Due to the slowness in movement on the road of beef on the hoof (about 4 km. an hour) an effort is always made to obviate this if possible. As has been shown, the park with the meat train can be operated 75 kilometers behind the troops. This is about 3 days' march under the most favorable con-

ditions for the troops. When a rapid advance is undertaken, a portion of the personnel of the cattle park is sent forward to a point farther advanced, and cattle are shipped in and held in anticipation of the arrival of the remainder of the personnel. When all the cattle have been slaughtered at the first place, the tools and equipment are loaded in an autotruck and sent forward to the new position. Thus, within a few hours the park can be advanced, if necessary, 3 days' march. The corps meat train is the only corps train to which autotrucks are regularly assigned. The autotruck in this case is a "transportation unit" pure and simple and does not provide the means for transporting a "rolling reserve." The rolling reserve of meat is carried in the corps supply train.

The corps supply train carries two days' strong ration and two days' oats.

The load consists of the following supplies:

Field or hard bread, two days.

(If the train is operating as a connecting link, field bread is carried, or, as a rolling reserve, hard bread is carried):

Salt	days	2
Dried vegetables	day	1
Rice	do	1
Sugar (1 day's strong and 1 day's reserve ration)	days	2
Coffee (1 day's strong and 1 day's reserve ration)	do	2
Oats (figured on a basis of 12.10 lbs. per animal)	do	2

APPENDIX.

1. COMPOSITION OF THE RATION.

Articles.	Reserve ration.	Strong ration.	Normal ration.
Bread:			
Soft (pounds)		1.65	1.65
Field (do)		1.54	1.54
Hard (do)	[1] 0.66	[2] 1.32	[2] 1.32
Meat:			
Fresh (do)		1.10	.88
Canned (seasoned) (do)	.66	.66	.44
Dried vegetables or rice (do)		.22	.132
Small store:			
Salt (do)		.044	.044
Sugar (do)	.176	.0704	.0462
Coffee, roasted, in tablets (do)	.0792		
Coffee, roasted, in tablets or loose (do)		.0528	.0352
Coffee, green (do)		.0627	.0418
Lard (when fresh meat is issued) (do)		.066	.066
Potage salé (when canned meat is issued)	.11	.11	.11
Brandy (quarts)	.055		
To each man in bivouac or when specially ordered:			
Wine (do)		.2641	.2641
Beer (do)		.5282	.5282
Brandy (do)		.055	.055
Tobacco:			
"Caporal," for officers (pounds)	.044	.033	.033
"Cantine," for enlisted men (do)	.033	.033	.033

[1] 6 pieces, or crackers. [2] 12 pieces, or crackers.

EXTRAORDINARY SUPPLEMENTS AUTHORIZED.

(See text of report.)

1. One ration of wine, beer, or brandy.
2. Additional: One-third ration of bread. One-fifth ration of meat.
3. Increase of one-half, one-third, one-fourth of the complete "strong" or "normal" ration.

AUTHORIZED SUBSTITUTIVE EQUIVALENTS.

		Strong ration.	Normal ration.
Substitute for one ration of fresh meat (beef)	pounds	1.10	0.88
Veal, mutton, pork, rabbit, horse, or fresh fish	do	1.10	.88
Meat pudding, eggs, soft cheese	do	.825	.66
Codfish, salted	do	.66	.55
Bacon	do	.66	.55
Smoked meat, herring salted, or salted sardines	do	.55	.44
Cheese (Gruyère, Holland, Chester, Roquefort)	do	.55	.44
Sausage, small and large smoked, herring, smoked	do	.44	.33
Sardines in oil	do	.33	.22
Codfish, dried, meat powder	do	.275	.22
Cow's milk	quarts	2.6412	2.201
Substitute for one ration of dried vegetables or rice		.22	.132
Potatoes	pounds	1.65	.99
Turnips, carrots, or cabbage	do	2.2	1.32
Sauerkraut	do	1.32	.792
Canned vegetables	do	.264	.154
Wheat flour	do	.22	.132
Italian pastes (noodles, vermicelli, etc.)	do	.22	.132
Corn meal	do	.22	.132
Cheese, Gruyère or Holland	do	.154	.088
Cheese, soft	do	.242	.132

FIGURES UPON WHICH ALLOWANCES OF TRANSPORTATION FOR RATIONS ARE BASES.

The net weight of the reserve ration, not including brandy, is 1.6852 pounds.

The net weight of the strong ration, with field bread, canned meat, *potage salé*, and not including spirits, is 2.6972 pounds.

The net weight of the strong ration without meat and spirits, and including lard, is 1.9932 pounds.

APPENDIX NO. III.

Figure 210 shows a comparison of the shells of the two principal field guns of the present war. On the left is the "75" French shell and on the right is the German "77" shell.

C, hood; *D*, orifice of the fuse; *K*, portion of shell below copper belt; *O*, ogival end of shell; *P*, orifice of lighting; *R*, the point where the shell is engaged; *T*, copper belt; *V*, body of shell; *c*, fixation screw for hood; *i*, orifice of aeration for combustion; *m*, screw fixing the base of fuse; *n*, spur which lodges in a corresponding niche of the instrument used to adjust the fuse; *p*, notch which holds the instrument used to screw the ogival end of shell to the body; *s*, line of opening of shell at the time of explosion.

Figure 215 shows the mechanism of the firing brake of the "75"; *I*, the cannon in position of repose; *II*, the cannon at the moment the charge is fired;

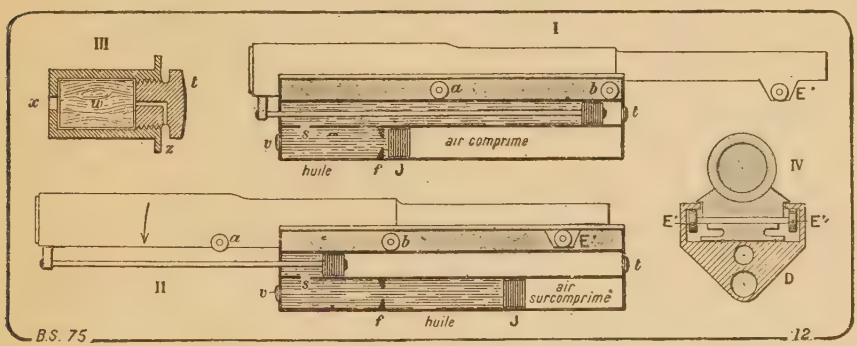


FIG. 215.—For description see text.

III, details of the forward cork valve of the firing brake; *IV*, vertical section of the mechanism of the cannon and brake; *D*, the arrangement of the cylinders in relation to the cannon; *E'*, rollers at the mouth of the cannon; *J*, diaphragm; *a* and *b*, rollers of the body of the cannon (they roll on the lower rail as an ordinary castor, while those of the mouth (*E'*) roll on the upper rail to the end of the recoil in order to secure the balancing of the cannon about *b*, in the sense indicated by the arrow, when the roller *a* leaves the rail); *f*, stops for the diaphragm; *s*, communicating opening between the two cylinders of the brake. In repose the lower cylinder contains, to the right of the diaphragm, air compressed to 120 atmospheres, which drives the diaphragm forcefully against the stops and thus pushes nearly all of the oil from the lower cylinder into the upper cylinder. At the moment of fire, the recoil throws the piston forcefully backward, the oil is forced into the lower cylinder and the diaphragm necessarily pushed against the compressed air. After the recoil has expended

itself, the powerful force of the compressed air is exerted on the diaphragm, pushing the latter against the oil. The piston is thus forced forward by the oil, and, since the piston is attached to the breech of the cannon, the latter moves forward with the piston until it resumes its normal position of repose. A too rapid return is avoided by the progressive flowing of the oil as it traverses the orifice *S*. The rod of the piston is fixed above to the breech by an automatic spring mechanism and this mechanism can not be detached (for cleaning or other reasons) unless the breech is open. When this mechanism is removed, an automatic safety device comes into play and prevents the closing of the breech. This ingenious arrangement has for the object the prevention of a serious accident which might occur if the cannon is fired while not being attached to the brake; *t*, valvelike stopper at the forward end of the upper cylinder to allow for the admission and departure of atmospheric air during the process of recoil and return; *v*, stopper which is screwed into the opening at the posterior end of the lower cylinder; *III* (details of the stopper *t*); *x*, communication of the valve with the chamber of the piston; *Z*, communication with the atmosphere; *W*,

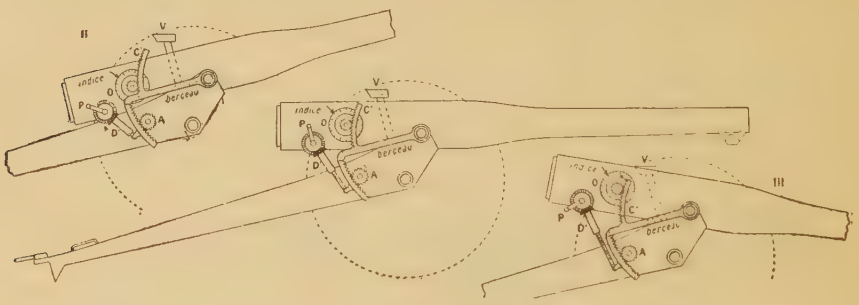


FIG. 216.—For description see text.

cylinder of wood which plays liberally in the socket and prevents the accumulation of dust.

Figure 211 shows the apparatus for aiming and sighting; *E'*, slide upon which the entire gun mechanism is shifted to right or left; *H'*, socket for sliding mechanism; *H*, wheel for controlling the sliding mechanism; *L*, wheel for obtaining the proper angle of sight; a turn of this wheel modifies the inclination of the cradle about 16 mm; *L'*, lock fixing wheel in position determined; *N*, small spirit level; *S*, collar upon which the sight rests evenly; *T*, drum for regulating sight mechanism; *V*, sight; *c* and *d*, hemispheres containing the ratchet-wheel mechanism which transmits the movement of the wheels *H* and *L*; *i*, sight gauge; *S*, guide which serves to find the inclination of the cannon below which it is not permitted to fire the gun because of the danger of firing through the mask which hides the gun. One obtains this information by looking at three points, the offset, the guide, and the summit of the barricade. The minimum back sight is written in chalk on the back of the shield and the gunner can not disregard this, even by order of the captain, who might have forgotten it, as these pieces often fire over friendly heads, and it is absolutely necessary to insure that the firing will not be too low.

Figure 216 explains the mechanism of the bridge. The three positions show the variations of the bridge, occasioned by the angle of firing, which has no

influence upon the sight. *A*, cogwheel which moves the cradle; *C'*, solid rack of the cradle moving the indicator of the bridge; *D*, solid nut of the breech which moves upon a fixed screw of the cradle. The rotation of this nut by means of a crank (*P*) varies position of the breech in accordance with the cradle. *O*, indicator of the bridge which is graduated into distances from 0 to 5,500 meters; *P*, crank serving to vary the inclination of the breech without changing the angle of sight.

Figure 213 gives a view of the cannon from the rear; *E*, slide upon which the lateral movements are made; *H*, wheel controlling lateral movements, placing the cannon in the direction of its aim and allowing a fan-shape method of firing; *L*, wheel for controlling the angle of fire; *M*, wheel skate and brake; *N*, handle of breech; *P*, seats for the gun pointer on the left and the firer on

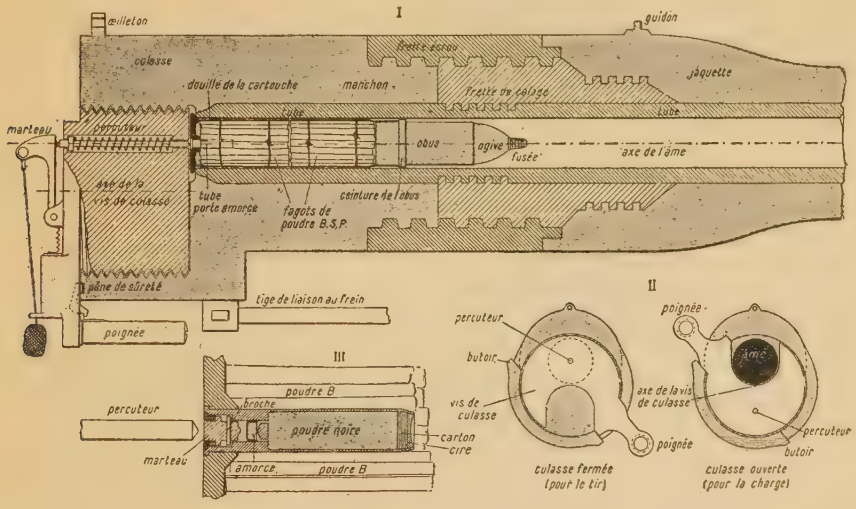


FIG. 217.—For description see text.

the right; *V*, sight; *a*, sack holding extra parts belonging to sight; *b*, pouch for holding small-arms ammunition; *c*, and *d*, hemispheres containing the cog-wheel transmission of the movements of the wheels *H* and *L*; *e*, notch of the breech screw; *h*, rib of the skates; *r*, offset to guide; *s*, guide.

Figure 214 shows the breech of the cannon open. *A*, opening; *B*, chamber, *D*, body of the brake; *D'*, mechanism controlled by the crank *P* in connection with the movements of the breech; *J*, ball for fixing gun by sliding on cord; *N*, handle of breech crank; *n*, automatic shell-case ejector; *q'*, point upon which the breech crank impinges when breech is closed; *r*, offset; *s*, guide.

Figure 212 shows the maximum recoil of gun on its carriage. *a*, rear roller; *D*, body of the brake; *E*, mouth of the gun; *F*, piston rod of brake.

Figure 217 shows sections of the body and breech of the gun with the French technical names for all the parts.

Figure 218 shows the mechanism of the breech safety-device with the French technical names for the parts. *A'*, tube containing spring. The latter when

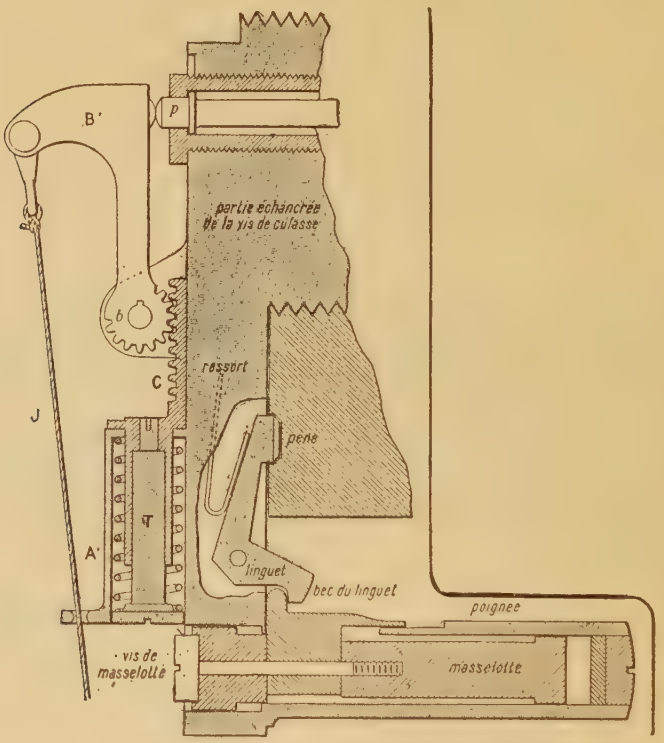


FIG. 218.—For description see text.

compressed forces the hammer *B'* against the firing pin *p*, causing the shell to be fired. *T*, spring holder; *C*, arm of spring mechanism; *b*, teeth of hammer; *J*, cord used to pull hammer back in firing.

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